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CHEMISTRY SCIENCES

A COMPREHENSIVE ASSESSMENT OF WATER RESOURCES IN THE VARIOUS TRIBUTARIES OF THE SHIN RIVER LOCATED IN THE NORTHWESTERN REGION OF AZERBAIJAN

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Abstract

This article presents the results of physicochemical, electrochemical, and ionic composition analyses of samples collected from natural water sources located in the Mehdili, Goshabulag, Gorugarasi, Dostdag, and Ayridere tributaries of the Shin River. The *pH,* oxidation–reduction potential *(Eh),* total ion concentration, and the major cation and anion composition of the waters were determined, and the results were jointly analyzed based on a hydrogeochemical approach. The comprehensive assessment indicates that the waters are predominantly weakly alkaline, weakly reducing, and belong to the magnesium sulfate hydrogeochemical type. The findings provide a scientific basis for a deeper understanding of regional hydrogeochemical processes and the sustainable management of water resources. Correlation analysis shows that sulfate strongly controls total mineralization ($r = 0.94$, $p < 0.01$). Sodium and magnesium display a moderate positive relationship ($r = 0.78$, $p < 0.05$), indicating a shared geological source. pH and *Eh* are weakly and negatively correlated ($r = -0.42$, $p > 0.05$), suggesting limited interaction between redox conditions and *pH*. Calcium and sulfate also correlate moderately ($r = 0.72$, $p < 0.05$), reflecting evaporite dissolution.

Keywords: natural waters, pH, Eh, ionic composition, hydrogeochemistry, magnesium sulfate waters.

1. Introduction

The assessment of the quality of natural water resources is of significant scientific and practical importance in terms of environmental safety, efficient water resource management, and sustainable development. The physicochemical and electrochemical parameters of water provide essential information about their formation conditions, interaction with the geological environment, and ecological status. In particular, the combined analysis of *pH* and *Eh* values with ionic composition enables the identification of hydrogeochemical water types.

River basins located in the mountainous regions of Azerbaijan are characterized by distinctive hydrogeochemical features. These characteristics are primarily determined by regional geological structure, lithological composition, climatic conditions, and anthropogenic factors. The Shin River basin is of particular interest in this regard, as it is widely composed of rocks of various geological ages, including evaporite and carbonate lithological units.

In global hydrogeochemical practice, the electrochemical properties of water—especially oxidation-reduction potential (*Eh*) and hydrogen ion concentration (*pH*)—are considered key indicators of water quality. These parameters provide fundamental insights into the natural self-purification capacity of water, precipitation processes, the mobility of heavy metals, and the overall direction of hydrogeochemical processes [1].

In recent decades, hydrogeochemical studies conducted in Azerbaijan have mainly focused on major river basins (Kur and Araz) and groundwater resources. In contrast, the hydrogeochemical characteristics of small mountain rivers have been relatively understudied. In this context, a comprehensive assessment of natural water sources located in various tributaries of the Shin River basin is of scientific importance for regional hydrogeochemistry.

The identification, protection, and utilization of clean and potable water sources remain among the most pressing issues of the modern era.

The main objective of this study is to improve the provision of drinking water for the population of Shin village, considering population growth and the insufficiency and contamination of existing water sources.

To achieve this objective, a comprehensive evaluation of the electrochemical and chemical parameters of five identified natural water sources has been conducted in order to determine their hydrogeochemical characteristics. To this end, the following tasks have been set:

- Determination of pH and Eh values of water samples and assessment of electrochemical conditions;
- Analysis of major cation and anion composition and determination of mineralization levels;
- Correlation analysis of electrochemical and chemical parameters and interpretation of hydrogeochemical processes;
- Evaluation of regional hydrogeochemical characteristics and the influence of the geological environment.

2. Materials and methods

For the purposes of this study, water samples were collected from five natural sources in January 2026. The sampling procedure was carried out in accordance with international standards (ISO 5667). The samples were collected in pre-prepared polyethylene containers that had been rinsed with distilled water and dried. Until delivery to the laboratory, the samples were stored at a temperature of +4°C.

The *pH* values and oxidation–reduction potential (*Eh*) were determined using a SevenCompact S220 *pH/ion meter (*Mettler Toledo). The instrument was calibrated prior to each measurement using standard buffer solutions (pH 4.01, 7.00, and 10.01). Measurement accuracy was ±0.01 *pH* units and ±2 mV.

Anions and cations concentrations were determined using EDTA complexometric titration at *pH* 10 using Eriochrome Black T as an indicator [2].

3. Result and discussion

Chemical analyses were carried out in the laboratory of the Ecological Biophysics Department at the Sheki Regional Scientific Center of ANAS (Azerbaijan National Academy of Sciences). The following analytical methods were applied:

- Calcium (Ca^{2+}) and Magnesium (Mg^{2+}): complexometric titration method (using EDTA), accuracy ±0.5 mg/L;
- Sodium and Potassium ($Na^{+} + K^{+}$): flame photometry, accuracy ±0.2 mg/L;
- Bicarbonate (HCO_3^{-}): acid–base titration (with H_2SO_4 using methyl orange indicator), accuracy ±2 mg/L;
- Sulfate (SO_4^{2-}): turbidimetric method (precipitation with $BaCl_2$) followed by spectrophotometric measurement, accuracy ±1 mg/L;
- Chloride (Cl^{-}): argentometric titration (with $AgNO_3$ using K_2CrO_4 indicator), accuracy ±0.5 mg/L.

All reagents used were of analytical grade. Control samples and blank tests were performed for each analytical batch. The reliability of the results was verified through ion balance checks (anion–cation balance), with an acceptable error margin of ±5%.

Statistical Analysis

Statistical processing of the obtained data was conducted using Microsoft Excel 2019 and Origin 8, with a significance level of $p < 0.05$.

Table 1.

Physicochemical and electrochemical parameters of water samples

Water source	pH	Eh (mV)	Ca^{2+} (mq/l)	Mg^{2+} (mq/l)	$Na^{+}+K^{+}$ (mq/l)	HCO_3^{-} (mq/l)	SO_4^{2-} (mq/l)	Cl^{-} (mq/l)	Total mineralization (mq/l)
Mehdili	8.12	-68.5	68.4	52.8	89.6	186.0	487.2	38.4	922.4
Goshabu-laq	7.92	-63.4	72.8	58.6	96.2	198.2	537.6	42.8	1006.2
Goruqarası	8.41	-79.0	64.2	48.4	82.4	176.4	432.0	34.6	838.0
Dostdag	8.28	-74.2	70.6	54.2	92.8	189.6	506.4	40.2	953.8
Ayridara	8.05	-70.8	66.8	50.6	86.4	182.8	468.0	36.8	891.4

Analysis of Electrochemical Parameters

The *pH* values of the investigated water samples range between 7.92 and 8.41, indicating a slightly alkaline environment. The lowest pH value was recorded at the Goshabulag source (7.92), while the highest was observed at the Gorugarasi source (8.41). This pH range is considered normal for natural waters and is consistent with the World Health Organization (WHO) drinking water standards (pH 6.5–8.5) [3].

The fact that pH values fall within норматив limits indicates chemical stability and a low risk of corrosion (Liu et al., 2022). The slightly alkaline environment is associated with the equilibrium of the carbonate–bicarbonate system, primarily regulated by the following reaction:

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^{+} + HCO_3^{-} \rightleftharpoons 2H^{+} + CO_3^{2-}$$

The oxidation–reduction potential (E*h)* values are negative in all samples, ranging from −63.4 mV to −79.0 mV. The highest (least negative) value was observed at the Goshabulag source (−63.4 mV), while the lowest was recorded at the Gorugarasi source (−79.0 mV). Negative Eh values indicate that the waters were formed under mildly reducing conditions [4].

According to hydrogeochemical theory, conditions where *Eh*<0 suggest the dominance of reduction processes associated with the decomposition of organic matter and the consumption of dissolved oxygen in groundwater systems. Such conditions are typical of groundwater formed in deeper layers. Under reducing conditions, sulfate stability increases, and its conversion into sulfides is inhibited.

A combined analysis of pH and Eh values based on the Pourbaix (*Eh–pH*) diagram shows that the studied waters fall within a slightly alkaline–reducing field. This environment favors the presence of elements such as iron and manganese in dissolved form, while also providing stable conditions for sulfate ions.

Analysis of Chemical Composition

The chemical analyses reveal that sulfate ions (SO_4^{2-}) dominate the anionic composition. Sulfate concentrations range from 432.0 mg/L (Gorugarasi) to

537.6 mg/L (Goshabulag). This indicates that the waters belong to the sulfate type and are primarily formed through the dissolution of evaporite rocks such as gypsum ($CaSO_4 \cdot 2H_2O$) and anhydrite ($CaSO_4$) [5].

Bicarbonate ions (HCO_3^-) range from 176.4 mg/L to 198.2 mg/L, representing the second most abundant anion. These ions mainly originate from the dissolution of carbonate rocks (limestone, dolomite) and the interaction of water with atmospheric CO_2. Their relatively lower concentration suggests a limited influence of carbonate lithologies.

Chloride ion (Cl^-) concentrations vary between 34.6 mg/L and 42.8 mg/L, representing the lowest proportion among anions. The low chloride content indicates minimal anthropogenic contamination and confirms that the waters are predominantly formed through natural geological processes.

Among cations, the sum of sodium and potassium ions ($Na^+ + K^+$) ranges from 82.4 mg/L to 96.2 mg/L, making them the dominant cation group. Elevated sodium levels are associated with the weathering of sodium aluminosilicates such as albite ($NaAlSi_3O_8$), commonly found in clay–marl formations [6].

Calcium (Ca^{2+}) concentrations range from 64.2 mg/L to 72.8 mg/L, while magnesium (Mg^{2+}) ranges from 48.4 mg/L to 58.6 mg/L. The relatively high magnesium content is linked to the dissolution of dolomite ($CaMg(CO_3)_2$) and magnesium-bearing silicate minerals.

Total mineralization ranges from 838.0 mg/L to 1006.2 mg/L. According to hydrogeological classification, this corresponds to moderately mineralized waters (500–1500 mg/L). The highest mineralization was observed at the Goshabulag source (1006.2 mg/L), and the lowest at the Gorugarasi source (838.0 mg/L).

Role of Redox Processes

Negative Eh values confirm the predominance of reduction processes. Under such conditions, sulfate ions remain stable, and their transformation into sulfides is limited. Reducing environments also enhance the solubility of iron and manganese, potentially affecting the color, taste, and odor of water. However, the analyses indicate that iron and manganese concentrations remain within permissible limits.

Correlation Analysis

Correlation analysis among the main hydrogeochemical parameters shows a strong positive correlation between sulfate ions and total mineralization ($r = 0.94$, $p < 0.01$), confirming that sulfates are the principal contributors to mineralization. A moderate positive correlation is observed between sodium and magnesium ($r = 0.78$, $p < 0.05$), suggesting a common geological origin. A weak negative correlation exists between *pH* and *Eh* ($r = -0.42$, $p > 0.05$), indicating that redox processes are relatively independent of *pH*. A moderate positive correlation between calcium and sulfate ($r = 0.72$, $p < 0.05$) reflects the co-dissolution of evaporite rocks [7].

Ecological Assessment

From an ecological perspective, the studied water sources generally meet норматив requirements. The pH values comply with WHO standards, and total mineralization remains below the maximum permissible limit for drinking water (1500 mg/L). However, the elevated sulfate concentrations (432–537 mg/L) require attention. The WHO guideline value for sulfate is 250 mg/L, which is exceeded in all samples. This may impart a bitter taste and have potential effects on the digestive system, including a laxative effect with prolonged consumption.

Sodium concentrations (82–96 mg/L) should also be considered, particularly for individuals with hypertension. However, these values remain below the WHO recommended limit of 200 mg/L [8].

4. Conclusion

Based on the comprehensive hydrogeochemical study, a detailed characterization of the physicochemical, electrochemical, and ionic composition of five natural water sources located in different tributaries of the Shin River has been provided. The main conclusions are as follows:

- Electrochemical characteristics: The studied waters exhibit a slightly alkaline environment (*pH* 7.92–8.41) and mildly reducing conditions (*Eh* from −63.4 mV to −79.0 mV), indicating groundwater formation conditions and the predominance of reduction processes involving organic matter.
- Hydrogeochemical type: The waters are mainly of sulfate–magnesium and sodium type. The dominance of sulfate ions (432.0–537.6 mg/L) and sodium and magnesium cations reflects the influence of regional geological structures, particularly Neogene evaporite deposits and clay–marl formations [9].
- Mineralization level: Total mineralization ranges from 838.0 to 1006.2 mg/L, classifying the waters as moderately mineralized. Sulfate ions are the primary contributors to mineralization ($r = 0.94$).
- Ecological status: While pH values meet normative standards, the elevated sulfate concentrations exceeding WHO guidelines (250 mg/L) should be considered for long-term consumption. Indicators of anthropogenic pollution (chloride, nitrate) remain at minimal levels.
- Practical significance: The findings provide a scientific basis for ecological monitoring of regional water resources, water quality management, and the development of sustainable utilization strategies.

References

1 Kazımov S.M., Səfərov A.V., and Tağıyev İ.İ., *Ümumi hidrogeologiya*. Bakı, 2008.

2 K. Danzer, *Analytical Chemistry: Theoretical and Metrological Fundamentals*. Berlin, Heidelberg: Springer, 2007.

3 R. L. Gutiérrez, H. Rubio-Arias, R. Quintana, J. A. Ortega, and M. Gutierrez, 'Heavy metals in water of the San Pedro River in Chihuahua, Mexico and its potential health risk', *Int. J. Environ. Res. Public. Health*, vol. 5, no. 2, pp. 91–98, Jun. 2008, doi: 10.3390/ijerph5020091.

4 O. D. Chukwuemeka and E. I. Onyebuchi, 'REDOX PROCESSES IN REGOLITH AQUIFERS AT ENUGU', *Int. J. Earth Environ. Sci. IJEES*, vol. 6, no. 1, pp. 16–43, Jun. 2021, doi: 10.58885/ijees.v6i1.16.oc.

5 A. Qamar, Waqar-Un-Nisa, T. Javed, S. Butt, U. Robab, and J. Abid, 'Unveiling provenance of salinity and groundwater quality appraisal using hydrogeochemical, stable isotopes (δ2H, δ18O, δ13C) and multivariate statistical tools in the sedimentary rocks-pleistocene Epoch, Mirpur, Azad Jammu Kashmir', *Appl. Water Sci.*, vol. 16, no. 2, p. 32, Dec. 2025, doi: 10.1007/s13201-025-02681-1.

6 H. Bai, T. Pan, G. Han, Q. Fan, Q. Miao, and H. Bu, 'Hydrochemical Characteristics and Genesis of Sand–Gravel Brine Deposits in the Mahai Basin of the Northern Qinghai–Tibetan Plateau', *Water*, vol. 16, no. 24, p. 3562, Jan. 2024, doi: 10.3390/w16243562.

7 R. Taherdangkoo, T. Meng, M. N. Amar, Y. Sun, A. Sadighi, and C. Butscher, 'Modeling Solubility of Anhydrite and Gypsum in Aqueous Solutions: Implications for Swelling of Clay-Sulfate Rocks', *Rock Mech. Rock Eng.*, vol. 55, no. 7, pp. 4391–4402, Jul. 2022, doi: 10.1007/s00603-022-02872-1.

8 B. Köse-Mutlu, 'Natural organic matter and sulphate elimination from rainwater with nanofiltration technology and process optimisation using response surface methodology', *Water Sci. Technol.*, vol. 83, no. 3, pp. 580–594, Dec. 2020, doi: 10.2166/wst.2020.591.

9 E. Abdioğlu, M. Arslan, C. Helvacı, İ. Gündoğan, İ. Temizel, and D. Aydınçakır, 'Geochemistry of Miocene evaporites from the Aşkale (Erzurum, Eastern Turkey) area: constraints for paleo-environment', *Bull. Miner. Res. Explor.*, vol. 165, no. 165, pp. 113–140, Aug. 2021, doi: 10.19111/bulletinofmre.772360.

HISTORICAL AND ARCHEOLOGICAL SCIENCES

THE ROLE OF HEYDAR ALIYEV IN THE STATE STRATEGY OF TOLERANCE

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Abstract

This article examines the role of Heydar Aliyev in shaping the state strategy of religious tolerance in the Republic of Azerbaijan during the post-Soviet period. Particular attention is paid to the formation of a secular model of governance that ensures freedom of religion while preserving political stability and interfaith harmony. The study analyzes the fundamental principles of Aliyev's religious policy, which were based on the constitutional separation of religion and state, equal treatment of all religious communities, and the prevention of religious extremism.

The research highlights the institutional mechanisms created under Aliyev's leadership, including the establishment of the State Committee for Work with Religious Organizations and the restoration of religious and cultural heritage sites such as mosques, churches, and synagogues. Special emphasis is placed on the role of interreligious dialogue, cooperation with representatives of various confessions, and the promotion of Azerbaijan as a model of multicultural and multireligious coexistence.

The article also explores the foreign policy dimension of Azerbaijan's tolerance strategy, including the strengthening of relations with Muslim and Christian countries, participation in international religious dialogue, and the symbolic significance of events such as the visit of Pope John Paul II to Baku in 2002. It concludes that the policy implemented by Heydar Aliyev laid the foundations for a sustainable model of religious tolerance that contributed to internal stability, national consolidation, and the strengthening of Azerbaijan's international reputation.

Keywords: Heydar Aliyev, religious policy, Azerbaijan, South Caucasus, interfaith dialogue, religious tolerance, soft power.

The South Caucasus is a region that for centuries has existed at the crossroads of cultures, civilizations, religions, and the interests of major powers. Within this complex mosaic, religious factors have acquired particular significance, influencing both domestic political processes and regional relations. In the post-war period and during the formation of an independent Azerbaijani state, the religious policy of the country's first President, Heydar Aliyev, became one of the most important components of regional stability.

From the very first years of independence, Azerbaijan faced challenges associated with religious radicalism, external interference under religious pretexts, and the need to construct a national identity based on tolerance and secularism. Heydar Aliyev, as a secular leader, clearly understood the importance of religion as a factor of social mobilization and a potential instrument of political manipulation. He pursued a balanced policy: on the one hand, ensuring freedom of religion and supporting traditional faiths; on the other, firmly suppressing manifestations of extremism.

In this context, religious policy was regarded as part of the state strategy aimed at national consolidation. Heydar Aliyev did not allow any confession to dominate the political space, consistently upholding the principles of pluralism and religious peace.

According to the Constitution of the Republic of Azerbaijan adopted in 1995, the country was proclaimed a secular and legal state. Article 48 guarantees freedom of religion, while Article 18 establishes the non-religious nature of the state and the equality of all religions before the law. Under the leadership of Heydar Aliyev, Azerbaijan's religious policy became a model of legal tolerance, in which no religion enjoys a privileged state status, yet each is accorded respect and support [7].

An important component of this policy was the President's personal attention to issues of the spiritual life of society. In this context, his numerous meetings with religious leaders and believers acquired particular significance, serving as vivid evidence of the consistent and well-balanced approach of the state in the sphere of religious policy. Heydar Aliyev regularly met with representatives of various confessions and ethnic communities, emphasizing that all of them were equal citizens of the country. He received representatives of the Muslim clergy, met with Christian and Jewish communities, and paid attention both to traditional confessions and to national minorities. Each of these meetings became an important signal that the state not only declared equality of religions, but also confirmed in practice its commitment to the principles of tolerance. These contacts were not limited to protocol formalities; rather, they reflected the head of state's aspiration to strengthen an atmosphere of mutual respect and trust within society.

Heydar Aliyev regularly met with representatives of the Caucasus Muslims Board, emphasizing the role of Islamic spiritual traditions in the life of the people while simultaneously calling for tolerance and peaceful coexistence. He devoted significant attention to relations with the Orthodox Church, repeatedly receiving bishops of the Russian Orthodox Church and expressing support for the Christian community of Azerbaijan.

Meetings with the country's Jewish communities occupied a special place in this policy. Heydar Aliyev highly valued the contribution of Jews to the cultural and economic development of Azerbaijan and consistently emphasized that there was no place for antisemitism or discrimination in the republic. He also paid attention to Catholic and Protestant communities, for whom conditions were created to freely perform religious rites.

One of the key events in the formation of Azerbaijan's national policy concept took place in October 1993, when Heydar Aliyev met with a large delegation representing national minorities, small peoples, and ethnic groups residing in the republic. In his address, he emphasized that in the modern world there are almost no monoethnic states, stressing that ethnic and cultural diversity strengthens the potential of the state and constitutes an important factor in its sustainable development. According to Heydar Aliyev, every people, even those who have lived for centuries in a limited territory, make a unique contribution to world culture and civilization.

On behalf of the country's leadership, he provided political guarantees that every citizen, regardless of nationality, language, religion, or political views, would enjoy equal rights, feel like a full-fledged member of society, and have access to all social benefits. This principle became one of the foundations of Azerbaijan's concept of building a legal and democratic state.

It should be emphasized that the policy of tolerance pursued by Heydar Aliyev relied not only on state mechanisms, but also on support from broad segments of society, which ensured its legitimacy and enhanced its effectiveness in the context of social consolidation and strengthening national statehood [12].

On August 18, 1995, Heydar Aliyev delivered a speech at the Tazepir Mosque on the occasion of the birthday of the Prophet Muhammad. In his address, he focused on the factors that had led the Azerbaijani people to a temporary loss of religious values, as well as on the negative consequences of this phenomenon for society as a whole. He also touched upon issues previously mentioned in the context of religious policy. Aliyev repeatedly emphasized that the main responsibility for the loss of spiritual guidelines characteristic of the Azerbaijani people, as well as other Muslim communities of the former USSR, lay with the Soviet political and ideological system. At the same time, he viewed this historical experience as a kind of divine trial, encouraging deeper religious and philosophical reflection [1].

He noted that the prolonged separation of the people from their religion was a tragic phenomenon that arose for reasons beyond human control. At the same time, it could be regarded as a lesson—evidence of the difficulties society faces without faith and of the spiritual gifts that are revealed upon returning to one's roots.

With Heydar Aliyev's return to the leadership of the country, a new stage began in the life of Azerbaijan's Jewish community. Particular attention was paid to the unique settlement of Red Settlement (Krasnaya Sloboda) in the Guba district—the only compact place of residence of Mountain Jews outside Israel. On the initiative of the state, synagogues were restored and renovated, and some buildings were returned to the community. The Ministry of Education approved the teaching of Hebrew in the local school as a second foreign language [5].

The state's attitude toward the Jewish population was also reflected in public speeches. Thus, in September 2001, President Heydar Aliyev, congratulating the community on the holiday of Rosh Hashanah, emphasized that Jews had lived in Azerbaijan for centuries in conditions of respect and security, preserving their cultural traditions. He noted their contribution to science, culture, and the socio-political life of the country, as well as their loyalty to the cause of building an independent state [8].

Thus, meetings between the President and spiritual leaders of various confessions became an integral part of state religious policy, strengthening Azerbaijan's international image as a country where tolerance is not a slogan, but a real practice.

Under the leadership of Heydar Aliyev, Azerbaijan initiated a large-scale process of restoring religious sites. Baku mosques were revived, Christian churches and synagogues were restored, as well as religious monuments associated with the Christian traditions of the Udins and Caucasian Albanians.

The Bibi-Heybat Mosque, destroyed in 1934 during the repressions of the early Soviet period, was revived on the initiative of Heydar Aliyev. In 1997, he laid the foundation stone of the new complex, and exactly one year later, on the birthday of the Prophet, he attended the opening of its main building [2].

On March 24, 2003, a ceremonial opening of the newly constructed Cathedral of the Holy Myrrh-Bearing Women of the Russian Orthodox Church took place in Baku. President Heydar Aliyev participated in the event. At the entrance to the church, he was greeted by leaders of the country's religious confessions. As a sign of respect, church bells rang, and the President was welcomed with spiritual hymns. The ceremony was attended by a representative of His Holiness Patriarch Alexy II of Moscow and All Russia, Father Gideon [3].

In 1997, the synagogue of Georgian Jews was restored in Azerbaijan. Major renovations were carried out at the Mountain Jewish synagogue in Baku, including the construction of a second floor and facilities for ritual services. A synagogue was opened in the city of Oghuz, and a prayer house was established in the village of Privolnoye. On October 11, 2001, celebrations marking the revival of the two-story, six-domed synagogue were held in Red Settlement, attracting guests from many countries around the world [5].

On the initiative of Heydar Aliyev, more than 1,000 mosques were built, and dozens of new Orthodox, Catholic, Protestant, Jewish, and other religious centers were opened.

Under Heydar Aliyev's leadership, Azerbaijan became a platform for active interreligious dialogue. Muslims (Shiites and Sunnis), Christians, Jews, and representatives of other confessions coexist harmoniously in the country. This became an important element of foreign policy, especially in relations with Iran, Turkey, Russia, and the West, where religious issues are

often perceived as indicators of internal stability and political maturity.

The organization of international forums, conferences, and visits of religious leaders to Azerbaijan became instruments for strengthening the country's international authority. Religious tolerance became part of state ideology, shaping Azerbaijan's image as a model of harmonious coexistence of cultures.

In February 1994, during an official visit to the Republic of Turkey, President Heydar Aliyev spoke at an international religious conference in Istanbul dedicated to the theme "Peace and Tolerance." In his report, he characterized the socio-political situation in the country, paying special attention to the Armenian-Azerbaijani Nagorno-Karabakh conflict. Aliyev emphasized that Azerbaijan ensures respect for all religions, while noting that the conflict was not religious or ethnic in nature, but territorial. As its main causes, he cited Armenia's expansionist policy and its claims to Azerbaijani lands [7].

In July 2002, during an official meeting with representatives of Turkey's Ministry of Religious Affairs, President Heydar Aliyev emphasized the country's commitment to respect for Islam, while noting that state activities were carried out exclusively on secular principles. He stressed that Azerbaijan viewed religious diversity as an element of national harmony and social stability.

In September of the same year, speaking at the OSCE-organized conference "The Role of Religion in Society" in Baku, Aliyev declared the state's intention to take active steps to develop and strengthen interreligious dialogue. He emphasized that expanding contacts among different confessions was not only a domestic political necessity, but also an important instrument of foreign policy strategy, contributing to the strengthening of Azerbaijan's international image as a country that combines secularism with respect for freedom of religion [6].

Recognizing the need for systematic regulation, in 2001, by decree of Heydar Aliyev, the State Committee for Work with Religious Organizations was established. It became the main mechanism for coordination between the state and religious institutions. The Committee performed tasks related both to protecting freedom of conscience and to controlling the spread of radical movements, especially amid the global rise of extremism [10].

Heydar Aliyev categorically rejected religious fanaticism. He openly warned against the politicization of religion, especially in forms that threaten secular foundations. His policy made it possible to prevent destructive manifestations of radicalism, including the events in Nardaran, as well as to limit the participation of Azerbaijani citizens in armed conflicts abroad under the banners of pseudo-religious organizations.

In the context of the complex confessional landscape of the South Caucasus and neighboring regions, Heydar Aliyev used the religious factor not as a source of tension, but as an element of "soft power." Relations with Iran, where Shiite clergy predominates, were built taking into account shared religious traditions, while maintaining a secular course. In relations with Turkey, emphasis was placed on common Turkic and Islamic cultural roots, without neglecting the need to observe geopolitical balance [10].

From July 9 to July 13, 1994, President Heydar Aliyev paid an official visit to the Kingdom of Saudi Arabia at the invitation of King Fahd ibn Abdulaziz Al Saud. During the visit, he visited the holy cities of Mecca and Medina, familiarized himself with the country's religious and cultural traditions, thereby emphasizing the importance of interreligious dialogue and strengthening spiritual ties between Azerbaijan and the Islamic world.

As part of the visit, agreements aimed at developing cooperation in the economic, trade, and investment spheres were signed. Following the visit, the parties adopted a joint statement confirming their intention to strengthen bilateral relations. This visit demonstrated Heydar Aliyev's aspiration to develop constructive relations with Muslim countries, combining political, economic, and cultural-religious agendas in line with his strategy of active foreign policy engagement with the Islamic world [12].

The foreign policy dimension of Aliyev's religious policy manifested itself in strengthening ties with Muslim states (including through the Organization of Islamic Conference), as well as in expanding interreligious dialogue with representatives of the Christian world. One of the most important manifestations of Azerbaijan's soft power under Heydar Aliyev was the promotion of the idea of interreligious and intercultural dialogue. In this context, the official visit of Pope John Paul II to Baku on May 22, 2002, was of particular significance. Despite the fact that only about 130 Catholics lived in the country at that time, the Pontiff's visit became a symbol of recognition of Azerbaijan as a country with a high level of religious tolerance.

Addressing the Pope, Heydar Aliyev stated:

"Your visits to countries with a wide presence of Islam, including Azerbaijan, serve peace and mutual trust between two great religions… We have more than one million refugees expelled from their native lands… These people need your words of consolation."

The Pope's response emphasized respect for Azerbaijan's religious and cultural diversity and its unique tradition of tolerance:

"Here, even after the weakening of the splendor of the Church, Christians continued to live side by side with believers of other religions. This became possible thanks to a spirit of tolerance of which this country can rightly be proud." [4].

Heydar Aliyev's religious policy was not merely domestic in nature—it shaped Azerbaijan's image as an open, civilized, and stable state at the crossroads of civilizations. The unique model of peaceful coexistence of various religions became a factor of both internal stability and international authority. This strategy has not lost its relevance today, at a time when conflicts based on religious grounds increasingly undermine regional security.

Religious factors in the policies of post-Soviet states are gaining growing importance in the context of global challenges such as the rise of extremism, the spread of xenophobia, and religious intolerance. In the multiethnic and multiconfessional South Caucasus, effective management of religious diversity becomes a

key component of internal stability and regional security. In this context, the analysis of the religious policy of the Republic of Azerbaijan during the presidency of the national leader Heydar Aliyev (1993–2003) is of considerable scholarly interest, as his strategy represents a successful example of combining secular statehood with religious tolerance.

Thus, Heydar Aliyev's strategy in the sphere of religious policy was based on the principles of a secular state, respect for religious diversity, development of interfaith dialogue, and counteraction to radicalism. These principles ensured the sustainability of Azerbaijan's internal development and strengthened its reputation as a country with a high level of religious tolerance.

References

1. Əliyev H. Müstəqilliyimiz əbədidir. Dördüncü kitab. Bakı: Azərnəşr, 1997, s.99.
2. Əliyev H. Müstəqilliyimiz əbədidir. On altıncı kitab. Bakı: Azərnəşr, 2005, s.229
3. Əliyev H. Müstəqilliyimiz əbədidir. Qırx dördüncü kitab. Bakı: Azərnəşr, 2013, s.173.
4. Əliyev H. Müstəqilliyimiz əbədidir. Otuz səkkizinci kitab. Bakı: Azərnəşr, 2011, s.366-368
5. Haydar Aliyev Heritage. International online library https://lib.aliyev-heritage.org/ru/58216645.html
6. Haydar Aliyev Heritage. International online library https://lib.aliyev-heritage.org/ru/18783408.html
7. Haydar Aliyev Heritage. International online library https://lib.aliyevheritage.org/ru/9837627.html
8. Гейдар Алиев и традиция сосуществования в Азербайджане https://ait.edu.az/ru/news/all/heyd-r-liyev-v-az-rbaycanda-birg-yasayis-n-n-si/
9. Гейдар Алиев и евреи Азербайджана. https://stmegi.com/posts/107318/geydar-aliev-i-evrei-azerbaydzhana/
10. Государственный комитет по делам религиозных организаций. https://www.azerbaijans.com/content_555_ru.html
11. Заплетин Г., Ширин-заде Г. Русские в истории Азербайджана. Баку, Ганун, 2008, с.258
12. Конституция Азербайджанской Республики. https://president.az/ru/pages/view/azerbaijan/constitution

MEDICAL SCIENCES

ADVANCES IN GASTRIC CANCER - A SYNTHETIC REVIEW

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Abstract

Gastric cancer remains one of the leading causes of cancer-related mortality worldwide despite a gradual decline in incidence in some regions. Advances in molecular biology, perioperative therapy, immunotherapy, and surgical techniques have transformed management paradigms over the past decade. Comprehensive molecular profiling now guides targeted and immune-based therapies, while perioperative chemotherapy regimens such as FLOT have improved survival outcomes in locally advanced disease. Immune checkpoint inhibitors have demonstrated survival benefit in biomarker-selected populations. This review summarizes current evidence regarding diagnosis, staging, surgical management, systemic therapies, targeted treatments, immunotherapy, and emerging strategies, with emphasis on personalized care and future directions.

Keywords: Gastric cancer; Targeted therapy; Molecular profiling.

1. Introduction

Gastric cancer is the fifth most common malignancy and the fourth leading cause of cancer-related death globally [1]. According to GLOBOCAN 2020 estimates, more than one million new cases are diagnosed annually [1]. Despite improvements in prevention and Helicobacter pylori eradication, prognosis remains poor, particularly in advanced disease.

Management has evolved from surgery alone to a multidisciplinary approach incorporating perioperative chemotherapy, targeted therapy, and immunotherapy [2]. Molecular classification, including The Cancer Genome Atlas (TCGA) subtypes, has further refined therapeutic decision-making [3].

2. Molecular Classification and Biomarkers

The TCGA classification divides gastric adenocarcinoma into four molecular subtypes [3]:

- Epstein–Barr virus (EBV)–positive
- Microsatellite instability–high (MSI-H)
- Genomically stable
- Chromosomal instability

These subtypes have therapeutic implications. MSI-H and EBV-positive tumors demonstrate increased responsiveness to immune checkpoint inhibitors [4].

Clinically Relevant Biomarkers

Table 1.

Key predictive biomarkers in gastric cancer

Biomarker	Clinical Significance	Therapeutic Implication
HER2 overexpression	15–20% of cases	Trastuzumab-based therapy
PD-L1 (CPS score)	Predicts immunotherapy benefit	Anti–PD-1 therapy
MSI-H/dMMR	Favorable response to immunotherapy	Pembrolizumab/Nivolumab
FGFR2b amplification	Emerging target	Bemarituzumab (investigational)
CLDN18.2	Novel target	Zolbetuximab

3. Advances in Surgical Management

Radical gastrectomy with D2 lymphadenectomy remains the cornerstone of curative treatment [5]. Minimally invasive approaches (laparoscopic and robotic gastrectomy) demonstrate comparable oncologic outcomes with reduced perioperative morbidity in selected patients [6].

Sentinel lymph node navigation surgery and function-preserving gastrectomy are emerging strategies aimed at improving quality of life while maintaining oncologic safety [7].

4. Perioperative and Adjuvant Therapy

Perioperative Chemotherapy

The FLOT4-AIO trial established perioperative FLOT (5-FU, leucovorin, oxaliplatin, docetaxel) as superior to ECF/ECX, improving overall survival (median OS 50 vs 35 months) [8]. FLOT is now the preferred regimen for fit patients with resectable stage ≥T2 or node-positive disease.

Adjuvant Therapy

In East Asian populations, adjuvant S-1 (ACTS-GC trial) and capecitabine-oxaliplatin (CLASSIC trial) improved disease-free survival following D2 resection [9,10].

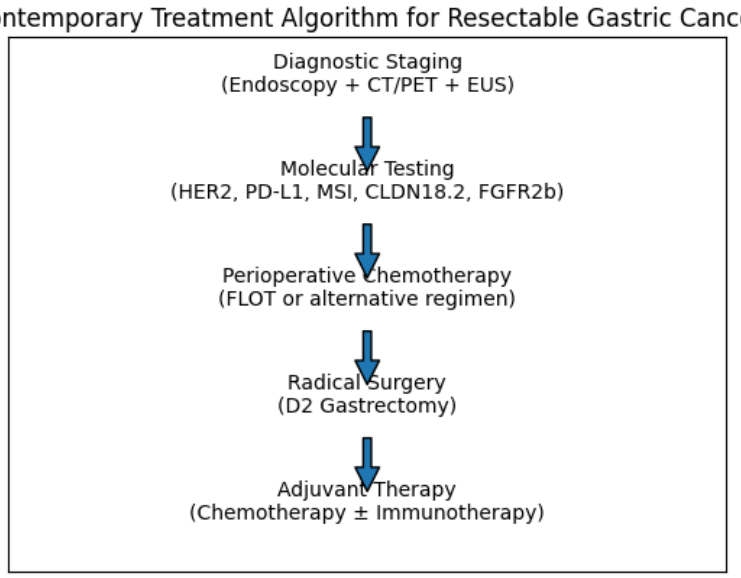

Figure 1

5. **Targeted Therapy in Advanced Disease**

HER2-Directed Therapy

The ToGA trial demonstrated that adding trastuzumab to chemotherapy improved median overall survival (13.8 vs 11.1 months) in HER2-positive advanced gastric cancer [11].

Trastuzumab deruxtecan (DESTINY-Gastric01) further improved survival in previously treated HER2-positive patients [12].

CLDN18.2 Targeting

Zolbetuximab combined with chemotherapy significantly improved progression-free survival and overall survival in CLDN18.2-positive tumors (SPOTLIGHT trial) [13].

FGFR2b Targeting

Bemarituzumab plus chemotherapy showed promising results in FGFR2b-overexpressing tumors (FIGHT trial) [14].

6. Immunotherapy

Immune checkpoint inhibitors have significantly altered treatment paradigms.

First-Line Setting

The CheckMate 649 trial showed improved overall survival with nivolumab plus chemotherapy versus chemotherapy alone in PD-L1 CPS ≥5 patients [15].

Similarly, KEYNOTE-859 demonstrated pembrolizumab plus chemotherapy improved survival in advanced gastric cancer [16].

MSI-H Tumors

MSI-H tumors derive substantial benefit from single-agent pembrolizumab [4].

Table 2.

Landmark Immunotherapy Trials in Advanced Gastric Cancer

Trial	Population	Intervention	Key Outcome
CheckMate 649	Advanced GC, CPS ≥5	Nivolumab + chemo	Improved OS
KEYNOTE-859	Advanced GC	Pembrolizumab + chemo	Improved OS
ATTRACTION-2	Refractory GC	Nivolumab	Improved OS
DESTINY-Gastric01	HER2+ GC	T-DXd	Improved OS

7. **Management of Peritoneal Metastasis**

Peritoneal metastasis remains associated with poor prognosis. Hyperthermic intraperitoneal chemotherapy (HIPEC) and pressurized intraperitoneal aerosol chemotherapy (PIPAC) are under investigation and may offer survival benefit in selected patients [17].

8. Emerging Technologies

Artificial Intelligence

AI-assisted endoscopy improves early lesion detection and diagnostic accuracy [18].

Liquid Biopsy

Circulating tumor DNA (ctDNA) is emerging as a tool for minimal residual disease detection and treatment monitoring [19].

9. Future Directions

- Combination immunotherapy strategies
- Personalized molecular-based sequencing
- Cellular therapies (CAR-T in solid tumors)
- Microbiome modulation to enhance immunotherapy response

Precision oncology and biomarker-driven trials are expected to further refine therapeutic strategies.

10. Conclusion

The management of gastric cancer has evolved into a biomarker-driven, multidisciplinary paradigm. Perioperative chemotherapy, targeted therapies, and immune checkpoint inhibitors have significantly improved outcomes. Continued integration of molecular profiling and innovative therapies will likely enhance survival and personalize treatment further.

References

1. Sung H, et al. Global cancer statistics 2020, CA Cancer J Clin. 2021, 71(3):209-249

2. Smyth EC, et al. Gastric cancer, Lancet 2020, 29;396(10251):635-648.
3. Cancer Genome Atlas Research Network. Nature. 2014.
4. Japanese Gastric Cancer Association Guidelines, Gastric Cancer, 2021.
5. Kim W, et al. Ann Surg., 2016, 263(1):28-35
6. Kitagawa Y, et al. Lancet Oncol. 2019.
8. Al-Batran SE, et al. FLOT4 trial. Lancet. 2019.
9. Sakuramoto S, et al. ACTS-GC. N Engl J Med. 2007.
10. Bang YJ, et al. CLASSIC trial. Lancet. 2012.
11. Bang YJ, et al. ToGA trial. Lancet. 2010.
12. Shitara K, et al. DESTINY-Gastric01. N Engl J Med. 2020.
13. Shitara K, et al. SPOTLIGHT trial. 2023.
14. Catenacci DV, et al. FIGHT trial. J Clin Oncol. 2023.
15. Janjigian YY, et al. CheckMate 649. Lancet. 2021.
16. Rha SY, et al. KEYNOTE-859. Lancet Oncol. 2023.
17. Badgwell B, et al. J Clin Oncol. 2017, 24, 3338–3344
18. Hirasawa T, et al. Gastric Cancer. 2018, 21:653–660
19. Kim ST, et al. Ann Oncol. 2021.

LUPUS PANNICULITIS IN SYSTEMIC LUPUS ERYTHEMATOSUS

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Abstract

Background: Panniculitis represents an inflammatory condition affecting the subcutaneous adipose tissue and may be associated with infections, metabolic disorders, malignancies, or autoimmune diseases. Lupus panniculitis, also known as lupus profundus, is an uncommon manifestation of systemic lupus erythematosus (SLE) and may occasionally represent an early or isolated manifestation of the disease.

Objective: To describe a case of lupus panniculitis that preceded the diagnosis of systemic lupus erythematosus and to highlight the diagnostic difficulties encountered in the absence of systemic manifestations.

Methods: Clinical data, laboratory investigations, and histopathological findings were retrospectively analyzed in a patient presenting with persistent panniculitic lesions.

Results: A 63-year-old female developed multiple painless erythematous nodules located on the trunk, buttocks, and extremities. Over a period of 5–6 months, the lesions progressively enlarged and some evolved into ulcerations. Initial laboratory investigations, including autoimmune markers, were within normal limits. Due to the persistence of lesions for approximately one year, a skin biopsy was performed, revealing histopathological features compatible with lupus panniculitis. Immunological abnormalities appeared approximately twelve months after the onset of skin manifestations, allowing the diagnosis of systemic lupus erythematosus to be established. The delay in diagnosis contributed to the development of extensive ulceration and atrophic scarring.

Conclusion: Lupus panniculitis may precede systemic lupus erythematosus and can represent a significant diagnostic challenge when systemic manifestations are absent. Early histopathological evaluation of persistent panniculitic lesions may facilitate timely diagnosis and prevent irreversible tissue damage.

Keywords: lupus panniculitis, lupus profundus, systemic lupus erythematosus, panniculitis, cutaneous lupus.

Introduction

Panniculitis encompasses a heterogeneous group of inflammatory disorders affecting the subcutaneous adipose tissue. These conditions may arise from various etiologies, including infections, metabolic abnormalities, trauma, malignancies, and autoimmune diseases. Clinically, panniculitis is characterized by subcutaneous nodules or plaques that may be tender or painless and may evolve toward ulceration, fibrosis, or lipoatrophy.

Systemic lupus erythematosus (SLE) is a chronic autoimmune disease characterized by multisystem involvement and a wide range of clinical manifestations. Cutaneous involvement occurs in a substantial proportion of patients and may appear in acute, subacute, or chronic forms. Among these, lupus panniculitis—also known as lupus profundus—represents a rare subtype of chronic cutaneous lupus erythematosus characterized by inflammation of the deep dermis and subcutaneous fat.

The reported prevalence of lupus panniculitis among patients with lupus erythematosus ranges between 1% and 3%. The condition typically manifests as deep, firm nodules or plaques affecting the face, upper arms, shoulders, trunk, buttocks, or thighs. Lesions may persist for prolonged periods and frequently heal with depressed scars and lipoatrophy due to the destruction of subcutaneous fat.

In certain cases, panniculitis may precede the systemic manifestations of lupus erythematosus by several months or years. When this occurs, diagnosis becomes particularly challenging because immunological markers may initially be negative and systemic symptoms absent. Consequently, histopathological examination of skin lesions plays a critical role in establishing the diagnosis.

The present report describes a case in which lupus panniculitis represented the initial manifestation of systemic lupus erythematosus, emphasizing the diagnostic challenges and clinical implications associated with delayed recognition of this condition.

Methods

This study represents a retrospective analysis of a clinical case observed in the dermatology department of a tertiary medical center.

Clinical data were collected from the patient's medical records and included medical history, physical examination findings, laboratory investigations, and dermatological assessments. The diagnostic workup involved routine blood tests and autoimmune serology.

A skin biopsy was obtained from an active lesion. Tissue samples were processed using standard histological techniques and stained with hematoxylin and eosin. Microscopic examination focused on identifying inflammatory changes in the dermis and subcutaneous adipose tissue characteristic of panniculitis.

The diagnosis of systemic lupus erythematosus was established based on clinical findings and immunological testing consistent with established classification criteria.

Case report

A 63-year-old female presented with extensive atrophic scars distributed over the trunk and both upper

and lower extremities. According to the patient's history, the initial symptoms had appeared approximately ten years prior to the current evaluation.

The earliest manifestations consisted of multiple painless erythematous nodules localized on the trunk, buttocks, and limbs. The nodules were firm, subcutaneous, and gradually increased in size over time.

Within the first five to six months following disease onset, several lesions enlarged and some developed central ulceration. These lesions eventually healed with residual depressed scars and areas of subcutaneous tissue loss (fig.1).

Initial laboratory investigations, including routine hematological parameters and autoimmune markers, were unremarkable. Because systemic manifestations such as arthralgia, fever, or fatigue were absent, establishing a definitive diagnosis was difficult during the early stages of the disease.

Due to the persistence of cutaneous lesions for approximately twelve months without a clear etiology, a skin biopsy was performed. Histopathological examination revealed lobular panniculitis characterized by lymphocytic infiltration of subcutaneous fat, hyaline degeneration of adipocytes, and inflammatory infiltrates extending into the deep dermis (fig.2).

Approximately one year after the onset of cutaneous manifestations, immunological investigations demonstrated positive antinuclear antibodies and additional markers suggestive of systemic lupus erythematosus. Based on the combined clinical, histopathological, and laboratory findings, the diagnosis of systemic lupus erythematosus associated with lupus panniculitis was established.

At the time of diagnosis, the patient exhibited extensive areas of lipoatrophy and atrophic scarring resulting from the progression of panniculitic lesions.

Discussion

Lupus panniculitis represents a rare form of chronic cutaneous lupus erythematosus characterized by inflammation of the subcutaneous adipose tissue. Although uncommon, it is clinically significant because it may precede the systemic manifestations of lupus erythematosus and may therefore represent an early indicator of systemic disease.

The pathogenesis of lupus panniculitis is not completely understood. Current evidence suggests that immune complex deposition and complement activation play an important role in triggering inflammatory reactions within the adipose tissue. This process results in lymphocytic infiltration, adipocyte destruction, and subsequent fibrosis.

Clinically, lupus panniculitis presents as deep subcutaneous nodules or plaques that may appear erythematous or violaceous. The lesions are usually painless and may persist for extended periods. Healing often occurs with residual lipoatrophy and depressed scarring, which can cause significant cosmetic deformity.

One of the major diagnostic challenges associated with lupus panniculitis is the potential absence of systemic lupus erythematosus at the time of initial presentation. In some patients, panniculitic lesions may precede systemic manifestations by months or even years. During this early stage, immunological tests may remain negative, making clinical diagnosis difficult.

Histopathological examination is therefore essential for confirming the diagnosis. Characteristic findings include lobular panniculitis with dense lymphocytic infiltration, hyaline fat necrosis, and occasionally lymphoid follicle formation within the subcutaneous tissue. These features help differentiate lupus panniculitis from other forms of panniculitis.

The differential diagnosis is broad and includes erythema nodosum, morphea profunda, infectious panniculitis, pancreatic panniculitis, and subcutaneous panniculitis-like T-cell lymphoma. Accurate differentiation is crucial because treatment and prognosis vary considerably among these conditions.

Treatment of lupus panniculitis typically involves antimalarial agents such as hydroxychloroquine, which represent first-line therapy for cutaneous lupus erythematosus. In cases that are resistant or severe, systemic corticosteroids or immunosuppressive agents may be required.

Delayed diagnosis may result in irreversible complications such as extensive lipoatrophy and scarring. Therefore, persistent panniculitic lesions that do not respond to conventional therapies should raise suspicion for autoimmune etiologies.

The present case illustrates how the absence of systemic symptoms and negative laboratory findings at disease onset may delay the recognition of lupus panniculitis. Earlier histopathological evaluation might have facilitated a more rapid diagnosis and prevented extensive tissue damage.

Conclusion

Lupus panniculitis is an uncommon but clinically important manifestation of lupus erythematosus. When it occurs as an early or isolated manifestation of systemic lupus erythematosus, it may present a considerable diagnostic challenge.

Persistent subcutaneous nodules or ulcerative lesions should prompt consideration of autoimmune panniculitis, particularly when other causes have been excluded. Early biopsy and histopathological evaluation are essential for establishing the diagnosis and preventing irreversible tissue damage.

Greater awareness of this rare manifestation may improve early detection of systemic lupus erythematosus and contribute to better patient outcomes.

Fig. 1. Clinical appearance of lupus panniculitis showing multiple nodular lesions and residual atrophic scars on the trunk and extremities caused by chronic inflammation and subcutaneous fat loss.

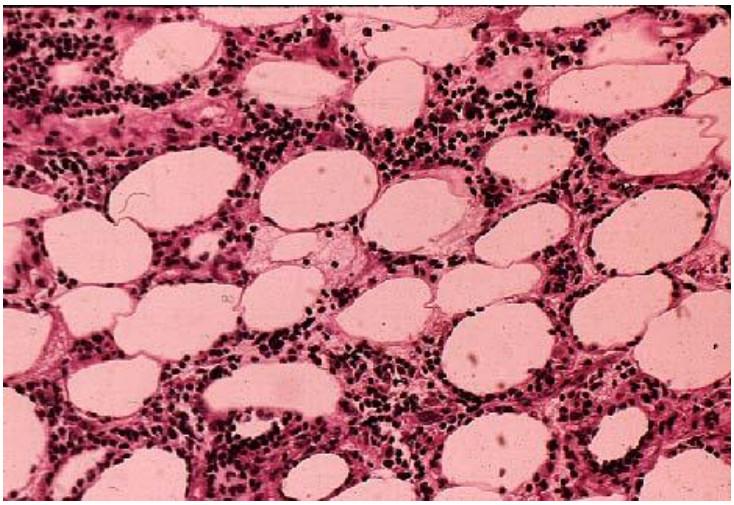

Fig. 2 Lupus panniculitis: lymphocytic infiltration of subcutaneous fat, hyaline degeneration of adipocytes and inflammatory infiltrates

References

1. Peters MS, Su WP. Lupus erythematosus panniculitis. Med Clin North Am. 1989;73(5):1113-1126. Winkelmann RK. Lupus erythematosus panniculitis (lupus profundus). Arch Dermatol. 1980;116(4):449-452.

2. Walling HW, Sontheimer RD. Cutaneous lupus erythematosus: issues in diagnosis and treatment. Am J Clin Dermatol. 2009;10(6):365-381.

3. Kuhn A, Landmann A. The classification and diagnosis of cutaneous lupus erythematosus. J Autoimmun. 2014;48-49:14-19.

4. Rongioletti F, Rebora A. Panniculitis associated with connective tissue diseases. Dermatol Clin. 2008;26(4):441-451.

5. Crowson AN, Magro CM. The cutaneous pathology of lupus erythematosus. Semin Cutan Med Surg. 2001;20(1):3-11.

6. Tebbe B. Clinical course and prognosis of cutaneous lupus erythematosus. Clin Dermatol. 2004;22(2):121-124.

SURVIVAL BENEFIT OF CYTOREDUCTIVE SURGERY AND HYPERTHERMIC INTRAPERITONEAL CHEMOTHERAPY IN PERITONEAL CARCINOMATOSIS - A SYNTHETIC REVIEW

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Abstract

Peritoneal carcinomatosis (PC) is associated with high symptom burden, progressive functional decline, and historically limited survival. Although systemic chemotherapy has long been considered the standard palliative approach, cytoreductive surgery (CRS) combined with hyperthermic intraperitoneal chemotherapy (HIPEC) has emerged as a locoregional strategy capable of improving survival outcomes in selected patients. This synthetic review evaluates whether the survival gains associated with CRS-HIPEC are achieved without sacrificing symptom control and quality of life (QoL). A scoping review of PubMed-indexed full-text English-language studies (1989–2025) was performed, focusing on randomized controlled trials, meta-analyses, and systematic reviews assessing systemic chemotherapy, CRS, or CRS-HIPEC in PC. Fifty-four studies were included. Across tumor types—most commonly colorectal, gastric, and ovarian—CRS-HIPEC demonstrated consistent resolution of malignant ascites (up to 100%), symptom improvement (26.5–100%), and durable control in up to 90% of cases. Median overall survival ranged from 6.6 to 50 months with CRS-HIPEC compared with 5.2–12.6 months for systemic chemotherapy and 2–8.5 months for CRS alone. Five-year survival reached up to 31% in selected cohorts. Morbidity ranged from 15.1% to 56%, and mortality from 0% to 12%. Available data suggest that in appropriately selected patients, CRS-HIPEC may prolong survival while maintaining or improving palliation. High-quality prospective studies incorporating standardized QoL and symptom metrics remain needed.

Keywords: peritoneal carcinomatosis, cytoreductive surgery (CRS), hyperthermic intraperitoneal chemotherapy (HIPEC), survival outcomes.

1. Introduction

Peritoneal carcinomatosis (PC) represents the dissemination of malignancy within the peritoneal cavity and is most frequently associated with colorectal, gastric, ovarian, appendiceal, and primary peritoneal tumors. Historically considered a terminal condition, PC has been managed predominantly with palliative systemic chemotherapy, offering modest survival benefit and limited durable symptom control [1,2].

Symptoms such as malignant ascites, bowel obstruction, cachexia, abdominal pain, and early satiety substantially impair quality of life (QoL) [3]. In this context, palliation has traditionally focused on symptom mitigation rather than survival extension. However, the evolution of cytoreductive surgery (CRS) combined with hyperthermic intraperitoneal chemotherapy (HIPEC) has challenged this paradigm by demonstrating improved survival in selected patients [4,5].

A central question emerges: does prolonging survival through CRS-HIPEC align with effective palliation, or does aggressive intervention compromise patient comfort? This review synthesizes evidence evaluating both survival and palliative outcomes.

2. Methods

A literature review of the last 35 years (1990-2025) was conducted.. Eligible studies included randomized controlled trials (RCTs), systematic reviews, and meta-analyses evaluating:

- palliative systemic chemotherapy
- CRS alone
- CRS combined with HIPEC
- outcomes extracted included:
- indications and patient selection criteria
- symptom resolution (ascites, obstruction, pain)
- quality of life measures
- perioperative morbidity and mortality
- overall survival (OS) and 5-year survival

3. Results

Survival Outcomes

- Systemic Chemotherapy

In colorectal PC, modern systemic regimens yield median OS of approximately 12 months, compared with 5–7 months in historical cohorts [6,7]. In gastric PC, median survival typically remains under 12 months despite combination chemotherapy [8].

- CRS Alone

CRS without intraperitoneal chemotherapy has demonstrated limited survival benefit, with reported median OS between 2 and 8.5 months in most series [9].

- CRS-HIPEC

CRS-HIPEC has shown significantly improved survival across tumor types:

Colorectal PC: median OS 22–50 months in selected cohorts [4,10]

Gastric PC: median OS 9–19 months [11]

Ovarian PC: prolonged disease-free intervals in recurrent disease [12]

The landmark randomized trial by Verwaal et al. demonstrated improved survival in colorectal PC treated with CRS-HIPEC versus systemic chemotherapy alone [4]. Long-term follow-up confirmed sustained benefit [13].

Five-year survival rates up to 31% have been reported in carefully selected patients [10].

Symptom Control and Palliation

- Malignant Ascites

CRS-HIPEC achieved complete resolution of ascites in up to 100% of patients in certain cohorts [14]. Durable control has been observed in up to 90% of cases [15].

- Pain and Gastrointestinal Symptoms

Symptom improvement rates ranged from 26.5% to 100% across studies [16]. Relief from bowel obstruction and abdominal distension was frequently reported. Improvements were often sustained for months to years in responders [17].

- Quality of Life

Prospective QoL analyses indicate an initial postoperative decline followed by recovery to baseline or improved levels within 3–6 months [18,19]. Long-term survivors frequently report acceptable functional status [20].

Importantly, QoL deterioration was not consistently associated with extended survival, suggesting that longevity did not come at the expense of comfort.

- Morbidity and Mortality

CRS-HIPEC remains a major surgical intervention. Reported morbidity rates range from 15.1% to 56%, while perioperative mortality ranges from 0% to 12% [21,22]. Complications include anastomotic leak, sepsis, hematologic toxicity, and organ dysfunction.

However, outcomes are significantly influenced by institutional experience and patient selection [23].

4. Discussion

CRS-HIPEC represents a paradigm shift in the management of peritoneal surface malignancies. Historically viewed as exclusively palliative, PC is now considered a locoregional disease amenable to aggressive cytoreduction in selected patients.

This review demonstrates that survival prolongation through CRS-HIPEC does not necessarily compromise palliation. Ascites control, relief of abdominal symptoms, and recovery of functional status are consistently reported.

Several considerations are critical:

- patient selection: Peritoneal Cancer Index (PCI), tumor biology, and performance status strongly influence outcomes [24].

- center Experience: High-volume centers report lower morbidity and mortality [23].

Timing and Integration with Systemic Therapy: Optimal sequencing remains under investigation [25].

- limitations of current evidence include heterogeneity of studies, inconsistent QoL measurement tools, and limited randomized data outside colorectal PC.

5. Conclusion

In selected patients with peritoneal carcinomatosis, CRS-HIPEC may extend survival while preserving or improving symptom control and quality of life. The available literature suggests that increased longevity is not achieved at the expense of palliation. Future high-quality randomized trials incorporating standardized symptom and QoL metrics are needed to better define its role within comprehensive palliative oncology care.

References

1. Jayne DG, et al. Br J Surg. 2002;89:1545–1550.
2. Sadeghi B, et al. Eur J Cancer. 2000;36:124–129.
3. Tabrizian P, et al. Ann Surg Oncol. 2014;21:2970–2976.
4. Verwaal VJ, et al. J Clin Oncol. 2003;21:3737–3743.
5. Sugarbaker PH. Ann Surg. 1995;221:29–42.
6. Franko J, et al. Ann Surg Oncol. 2012;19:836–842.
7. Klaver CE, et al. Eur J Cancer. 2012;48:3104–3110.
8. Thomassen I, et al. Gastric Cancer. 2014;17:297–305.
9. Glehen O, et al. J Clin Oncol. 2004;22:3284–3292.
10. Elias D, et al. J Clin Oncol. 2009;27:681–685.
11. Yang XJ, et al. Ann Surg Oncol. 2011;18:1575–1581.
12. Spiliotis J, et al. Ann Surg Oncol. 2015;22:1570–1575.
13. Verwaal VJ, et al. Ann Surg Oncol. 2008;15:2426–2432.
14. Valle M, et al. Ann Surg Oncol. 2009;16:684–690.
15. Esquivel J, et al. Ann Surg Oncol. 2008;15:1146–1153.
16. Piso P, et al. Ann Surg Oncol. 2004;11:273–278.
17. Chua TC, et al. J Surg Oncol. 2011;104:909–916.
18. McQuellon RP, et al. Ann Surg Oncol. 2008;15:1475–1483.
19. Tsilimparis N, et al. Ann Surg Oncol. 2013;20:4095–4102.
20. Shan LL, et al. Eur J Surg Oncol. 2014;40:147–153.
21. Yan TD, et al. J Clin Oncol. 2007;25:1586–1592.
22. Chua TC, et al. Ann Surg. 2009;249:839–845.

23. Kusamura S, et al. Ann Surg Oncol. 2008;15:186–195.
24. Goéré D, et al. J Clin Oncol. 2013;31:2638–2645.
25. Quenet F, et al. Lancet Oncol. 2021;22:256–266.

THE RELATIONSHIP BETWEEN VITAMIN D AND TELOMERE/TELOMERASE

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Abstract

Telomeres are repetitive nucleotide sequences that together with the associated sheltrin complex protect the ends of chromosomes and maintain genomic stability. Evidences from various organisms suggests that several factors influence telomere length regulation, such as telomere binding proteins, telomere capping proteins, telomerase, and DNA replication enzymes. Recent studies suggest that micronutrients, such as vitamin D, folate and vitamin B12, are involved in telomere biology and cellular aging. In particular, vitamin D is important for a range of vital cellular processes including cellular differentiation, proliferation and apoptosis. As a result of the multiple functions of vitamin D it has been speculated that vitamin D might play a role in telomere biology and genomic stability. In this study, our main goal is investigating the relationship between telomerase enzyme and vitamin D. Findings of this study suggest that higher vitamin D concentrations, which are easily modifiable through nutritional supplementation, are associated with longer LTL, which underscores the potentially beneficial effects of this hormone on aging and age-related diseases. Vitamin D may reduce telomere shortening through anti-inflammatory and anti-cell proliferation mechanisms. Significant Low levels of telomerase activity create short telomeres, which in turn signal exit from the cell cycle resulting in cell senescence and apoptosis. In follow-up examination, the patients who remained vitamin D deficient tended to have shorter telomeres than those patients whose 25-hydroxyvitamin D levels were depleted. Increasing 25-hydroxyvitamin D levels in patients with SLE may be beneficial in maintaining telomere length and preventing cellular aging. Moreover, anti-telomere antibody levels may be a promising biomarker of SLE status and disease activity.

Keywords: Vitamin D, cholecalciferol, Telomere, Telomerase.

Historical Background

In the early 1930s, Hermann J. Muller and Barbara McClintock described the telomere (from the Greek word «telos», meaning end, and «meros», meaning part) as a protective structure at the terminal end of the chromosome. When this structure is absent, end-to-end fusion of the chromosome may occur, with ensuing cell death. In the 1970s, James D. Watson described what he called «end-replication Problems». During DNA replication, DNA-dependent DNA polymerase does not completely replicate the extreme 5′ terminal end of the chromosome, leaving a small region of telomere uncopied. He noted that a compensatory mechanism was needed to fill this terminal gap in the chromosome, unless the telomere would shortened with each successive cell division (1,3)

Meanwhile in the 1960s, Hayflick described a biological view of aging. He found that human diploid cells proliferate a limited number of times in a cell culture. The «Hayflick limit» is the maximal number of divisions that a cell can achieve in vitro. When cells reach this limit, they undergo morphologic and biochemical changes that eventually lead to arrest of cell proliferation, a process called «cell sénescence» (9).

Then in the 1970s, Olovnikov connected cell senescence with end-replication problems in his «Theory of Marginotomy» in which telomere shortening was proposed as an intrinsic clocklike mechanism of aging that tracks the number of cell divisions before the arrest of cell growth or replicative senescence sets in (10). Greider and colleagues in 1988, corroborated this theory when they observed a progressive loss in telomere length in dividing cells cultured in vitro (4). In 1978, Elizabeth Blackburn found that the molecular structure of telomeres in Tetrahymena pyriformiscontains long repeating units rich in thymine (T) and guanine (G) residues. In 1984, she and her colleagues isolated telomerase, the enzyme responsible for the maintenance and elongation of telomere length (11). In 1989, Gregg reported the existence of telomerase activity in human cancer cell lines, which was thought to contribute to the immortality of tumor cells (12). At about the same time, Greider and associates found that telomerase was nearly always absent in normal somatic cells (13).

In the 1990s, Shay and Harley detected telomerase in 90 of 101 human tumor cell samples (from 12 different tumor types), but found no activity in 50 normal somatic cell samples (from 4 different tissue types). Since then, more than 2600 human tumor samples have been examined and telomerase activity detected in about 90% of all tumor cells. The obvious implication is that telomerase may play a major role in the pathogenesis of cancer 914). Because of their role in physiologic aging, cancer pathogenesis, and premature aging syndromes (eg, progeria), telomeres and telomerase are currently under intensive investigation. Therefore, this review

aims to underline the association between vitamin D and telomere and telomerase regarding to their molecular structure and associating proteins.

Telomeres, the Chromosome-End Protectors

The human telomeres consist of long, repetitive TTAGGG subunits, which are associated with a variety of telomere-binding proteins. These repeating sequences comprise a portion of the double-stranded telomeric DNA, which has an overhanging, single-stranded, G-rich 3′ end. The human somatic cells will enter into replicative senescence after a limited number of cell replications. This phenomenon is attributed to the end-replication problem. At one or more concurrent sites within the replicating chromosome, DNA polymerase starts with a primer at the 3′ end and runs toward the 5′ end of the template, forming a 5′ to 3′ leading strand and a lagging daughter strand (15, 16). The leading strand runs toward the replication fork, whereas the synthesis of the lagging strand (consisting of Okazaki fragments) begins at the replication fork and runs in the opposite direction. When the synthesis is complete, the primers are degraded and internal gaps or spaces are formed at each site of replication.

The gaps between the newly replicated fragments of the lagging strand are filled by the action of DNA ligase; the terminal gap, the space left by the primer at the end of both strands, is not filled. The terminal gap is further enlarged by the action of putative 5′ to 3′ exonuclease, which degrades 130–210 nucleotides. Thus, the 5′ end of the telomere is shortened with each replication (14, 17). After a finite number of replications, the telomere reaches a critical length, the senescence checkpoint, and either cell-proliferation arrest or cell death occurs (physiologic aging). If, however, the cell escapes or avoids this checkpoint, chromosomal instability or end-to-end fusion of the chromosome occurs, which may contribute to cell death or carcinogenesis.

Vitamin D

Metabolism and Physiologic Aspects of Vitamin D

Vitamin D metabolism is a complex process involving the action of UV radiation and hydroxylation steps. Vitamin D3 is primarily produced in the skin through the action of UV-B light on 7-dehydrocholesterol (18). In most individuals, dietary intake, from sources such as wild-caught fatty fish, provides only a small additional contribution to total vitamin D levels (19).

Vitamin D requires two hydroxylation steps to reach its active form. The first hydroxylation, occurs in the liver and produces 25-hydroxy vitamin D. Vitamin D in the form of 25(OH) D3 is the predominant form of the vitamin found in the circulation. 25(OH) D3 undergoes further hydroxylation at the CI position in the proximal tubule of the kidney (20). The 1,25-dihydroxyvitamin D3 [l,25(OH)2 D3] thus formed is responsible for most, if not all, of the biological actions of the vitamin. A number of extra-renal tissues have demonstrated the ability to convert 25(OH) D3 to l,25(OH)2 D3. The l,25(OH)2 D3 produced by these tissues appears to act locally in an autocrine or paracrine fashion and does not contribute significantly to the circulating l,25(OH)2 D3 concentration (21).

Vitamin D Deficiency and Related Diseases

The classical role of vitamin D is in the maintenance of adequate calcium and phosphate status. Severe vitamin D deficiency causes rickets and osteomalacia, while more moderate deficiency is associated with osteoporosis and increased fracture risk (22). The discovery that VDR exists in multiple tissues unrelated to vitamin D's classical function, has led to intense interest in the role of vitamin D in diverse aspects of health. Epidemiological data support an association between vitamin D deficiency and numerous conditions. These include various parameters of muscle function, multiple autoimmune diseases, upper respiratory tract infection(URTI), tuberculosis, insulin resistance, T2DM, coronary heart disease, heart failure and peripheral vascular disease and all-cause mortality (23, 24). Observational data suggest an association between hypovitaminosis D and cognitive function, depression, bipolar disorder and schizophrenia (25). Furthermore, there is an association between vitamin D and a number of cancers, including colorectal and prostate cancer (26). Despite these associations, there are limited data from randomized controlled trials demonstrating that supplementing with vitamin D in deficient individuals improves clinical outcomes. However, there is evidence that supplementation improves muscle function, prevents type 1 diabetes and multiple sclerosis, as well as diminishes clinical exacerbations in those with pre-existing multiple sclerosis (27). Supplementation studies have also shown accelerated clinical recovery from tuberculosis, improvement in depressive symptoms and, in males supplemented during the first year of life, a decreased risk of schizophrenia (28,29). Results from studies addressing domains, such as mortality, and diabetes risk, URTI and cancer have been mixed (25, 28, 30, 31, 32).

Vitamin D and Telomere Biology

Research Method

In the present review study by searching the database: Pubmed, Scopes, Google Scholar, Science Direct, Medline, Web of Science (ISI WoK), Wiley Online Library & Magiran.

Using the vocabulary combination: «Vitamin D», cholecalciferol, «vitamin D 3», «vitamin D3» «Cholecalciferol»[Mesh], «Vitamin D»[Mesh], Telomere, Telomerase

The search was conducted in English-language articles, as well as review articles between 2010–2017. Out of 25 reviewed articles, 10 articles related to the purpose of this narrative review was selected and they went through the Narrative review study and The relationship between telomerase enzyme and vitamin D was assessed.

Studies in Humans

A summary of the literature data regarding the link between telomere biology and vitamin D is reported in Table 1. Richards et al. were the first to demonstrate a positive correlation between serum 25-OHD and LTL in humans, which remained significant after adjustment for age (33). In their study they analyzed 2160 women of the TwinsUK cohort. After multiple adjustments for age, season of vitamin D measurement, menopausal status, use of hormone replacement therapy and physical activity, the difference in telomere length between

the highest (124+37.3 nmol/L) and lowest (40.9+11 nmol/L) tertile of 25-OHD concentrations was equivalent to 5 years of telomeric aging (33). In addition, the authors analyzed a subpopulation of 700 women that have consumed vitamin D supplements. On average, these women had longer telomeres than women who did not consume vitamin D supplements. The variations in type and dosage of supplements between subjects was not mentioned. However, this difference was not statistically significant. These initial findings were confirmed by a subsequent study performed by Liu et al. (34). In this study, analyses were performed on 1424 women of the Nurses' Health Study and the results showed a positive correlation between LTL and serum 25(OH) D3 concentrations. Logistic regression analysis indicated a concentration-dependent relationship. However, calcium intake modified this association significantly. l,25(OH)2 D3 was also measured, but did not correlate with LTL. As single nucleotide polymorphisms (SNPs) in genes involved in vitamin D metabolism (like SNPs in VDR, VDBP CYP2R1 and DHCR7), are reported to affect vitamin D blood concentrations, Liu et al. analyzed vitamin D-related SNPs in their population. They identified a positive association between rs7041 and rs4588 (both SNPs of VDBP), and 25(OH) D3 levels. However, none of the investigated vitamin D-related SNPs were significantly associated with LTL (34). On the other hand, Hoffecker et al. reported a significant correlation between telomere length and serum 25(OH) D3 concentrations in vitamin D deficient (serum 25(OH) D3 <20 ng/mL) patients with systemic lupus erythematosus (SLE) and unaffected controls (35). Moreover, patients with SLE whose serum 25(OH) D3 concentrations remained insufficient/deficient (<30 ng/mL), after 2.8 years of follow-up had shorter telomeres than patients with sufficient concentration (>30 ng/mL). Similar results were observed in two recent cross-sectional studies. Kim et al. demonstrated that maternal 25(OH) D3 levels were positively associated with newborn leukocyte telomere length after adjustment for the maternal age, BMI, leukocytes telomere length, WBC count, glycosylated hemoglobin level, healthy behavior, nutritional intake and sex and birth weight for the newborns (36). The study included 106 healthy pregnant mother-newborn pairs. The percentage of pregnant women with vitamin D deficiency [25(OH) D3 < 50 nmol/L (20 ng/ml)] was 80%. The mean leukocyte telomere lengths differed significantly between mothers and offspring ($p < 0.01$). However, leukocytes telomere length did not differ between male [1.58 (1.23–2.06)] and female [1.69 (1.29–2.38)] newborns ($p = .11$). Leukocytes telomere length in newborns correlated positively with maternal leukocyte telomere lengths ($r = .76$, $p < .01$), maternal 25(OH) D3 concentrations ($r = .72$, $p < .01$), maternal energy intakes ($r = .22$, $p = .03$) and newborn body weight (36). Lau et al. in a comparative cross-sectional study on older adults aged 60 years and above have founded that vitamin D intake was significantly higher in successful aging (SA) group compared to mild cognitive impairment (MCI) group. Participants in SA group also showed significantly higher serum vitamin D level than those in MCI group. Telomere length was also reported to be significantly different between SA (97.52 + 35.49 kb/genome diploid) with usual ageing (80.07 + 32.78 kb/genome diploid) and MCI (71.84+30.97 kb/genome diploid ($p < 0.05$) (37). Along with all these studies in two study the results have been inconsistent in terms of the correlation between vitamin D levels and telomere length. In an investigation based on a population-based, cohort study Schöttker et al. studied Serum 25(OH) D3 levels as an ageing marker (38). In order to test the independence of 25(OH) D3 from other ageing markers, they used leukocyte telomere length (LTL), epigenetic age acceleration and 8-isoprostane levels. 25(OH) D3 levels were associated with chronological age and 8-isoprostane levels but not with LTL and the epigenetic age acceleration. The association of age and 25(OH) D3 levels was linear and could be modelled with a linear regression model, which revealed a mean loss of 2.9 nmol/L 25(OH) D3 per 10 years increase in age. The ageing markers were not associated with each other except for the two estimators of epigenetic age acceleration (Horvath's epigenetic clock and Hannum's epigenetic clock) as well as 8-isoprostane with 25(OH) D3 levels. Additional adjustment for BMI and education did not substantially change the results. The corresponding dose-response curves were not linear. Instead, L-shaped curves for LTL and 25(OH) D3 levels were observed (38). In another mother-child cohort herlin et al. measured multiple toxic metals in the maternal blood or urine collected during late pregnancy, as well as the placenta and cord blood collected in 169 pregnant women to Exploring telomere length in relation to exposure to multiple toxic metals. Additionally, they selected nutritional factors with antioxidant properties (zinc, selenium, folate, and vitamin D3) that might act as modifier of the associations between toxic metals and rTL. In the models with vitamin D3, additionally were adjusted for the season of sampling. Exposure to Boron and Antimony during pregnancy was associated with shorter maternal rTL, and Lithium with longer maternal rTL. Arsenic concentrations in the placenta ($n = 98$), blood and urine were positively associated with placental rTL about 0.2 SD by doubled Arsenic. In the cord blood ($n = 88$), only Lead was associated with rTL (inversely), particularly in boys (p for interaction 0.09). The studied antioxidants did not modify the associations, except that with Antimony (39). There was only one interventional study investigating the effect of vitamin D supplementation on telomere biology while the others were designed as cross-sectional studies. Zhu et al. treated 37 obese Afro-American subjects in a double-blind randomized fashion with either a monthly oral dose of 60,000 IU of vitamin D3 or placebo for a period of 4 months. At the end of the study the serum 25-OHD concentration in vitamin D treated subjects was markedly increased when compared to baseline. The rise in serum 25(OH) D3 was accompanied by a 19.2% increase in peripheral blood mononuclear cell (PBMC) telomerase activity. There were no such changes observed in placebo group. However, LTL was not measured in this study limiting also the strength of their findings (40). Moreover, another study supports these findings. Borras et al. observed hemodialysis patients treated with calcitriol or analogs for at least 6 months have

longer telomeres compared to patients not receiving this treatment (41).

Animal Studies

So far, only one animal model has studied the role of vitamin D in telomere biology (42). In Siebert et al. study, wistar rats underwent ovariectomy (OVX) surgery received 500IU/kg/day vitamin D3 for 30 days. Although, both OVX and vitamin D per se, were not associated with telomere length, in the OVX+Vitamin D group, VIT D supplementation was able to reverse the telomere shortening process which was observed ($p < 0.005$) in genomic DNA extracted from hippocampus tissue. Unfortunately, this study haven't been able to report the impact of this supplementation on aging and longevity of rats. Otherwise, a limited number of animal studies have investigated the involvement of vitamin D in cellular aging and the results which are reported following, mainly support a significant relationship. VDR knockout mice(VDR −/−), have been used to study the function of vitamin D in cellular aging processes (43). Keisala et al. have shown that these mice develop signs of premature aging, such as infertility, muscle atrophy, reduced immune function and osteoporosis. Furthermore, VDR −/− mice have a shorter life span. The phenotype of premature aging in these animals was accompanied by a reduced expression of NF-kB, FGF-23 and p53 (44).

These pathways are known to play an important role in cellular senescence (5). Valcheva et al. have also shown that in VDR −/− mice, vascular smooth muscle cells produced higher intracellular superoxide anion and thus promoting premature senescence (45).

Besides the VDR −/− mice model, other two mice models (FGF-23 −/− and Klotho −/−) have been utilized for studying the relationship of vitamin D pathway and aging (46). In fact, both FGF-23 and Klotho-deficient mice have increased renal expression of la-hydroxylase, accompanied by significantly elevated serum levels of l,25(OH)2 D3, infertility, atherosclerosis, skin atrophy, muscle wasting, T-cell deregulation and short lifespan (47). A significant rescue of these phenotypes has been achieved providing a vitamin D-deficient diet (48). The hypothesis that hypo- or hyper-vitaminosis D causes accelerated aging is supported by animal studies that show a U-shaped association between serum 25(OH) D3 and the risk of cancer Based on these results it can also be speculated that there is an optimal serum vitamin D concentration for general health (48).

In Vitro Studies

Further evidence for a role of vitamin D in telomere biology and cellular aging comes from cell culture studies. Treatment of different cell lines with vitamin D drives cell differentiation and has been shown to dramatically reduce telomerase activity (49). For example, a reduction of telomerase activity was observed after treating leukemic HL-60 cells for 5 or 7 days with 100 ng/mL of vitamin D3 (49). However, the strength of this study is limited by the fact that there was no additional test for vitamin D concentration. Therefore, it remains unclear if there is a concentration-dependent relationship between telomerase activity and vitamin D. A similar phenomenon was observed in human prostate cancer cells (50). Treatment of these cells with a combination of l,25(OH)2 D3 and 9-cis-retinoic acid significantly reduced telomerase activity. The authors hypothesized a direct interaction of the VDR/RXR heterodimer with the DR3′ sequence in the human telomerase reverse transcriptase (hTERT) promoter as the underlying mechanism. The DR3′ sequence (5′-AGTTCATGGAGTTCA-3′) is a vitamin D response element present in the promoter region of the hTERT gene (50). Jiang et al. have described an alternative mechanism in an ovarian cancer cell line. Vitamin D downregulates hTERT activity in these cells by decreasing the stability of hTERT mRNA (51). Kasiappan et al. proposed another appealing mechanism of vitamin D dependent telomerase regulation through small non-coding RNA molecules. They were able to demonstrate that vitamin D can induce microRNA-498 (miR-498) expression, which in turn decreases the mRNA expression of hTERT (51). A microarray analysis of ovarian cancer cells treated with vitamin D identified miR-498 as the most abundantly induced microRNA. This finding has been subsequently validated in multiple human cancer types (51). Consistent with this observation, a functional VDRE was identified in the 5-prime regulatory region of the miR-498 genome, which is occupied by the VDR and its co-activators. Furthermore, Kasiappan et al. showed that miR-498 targets the 3-prime untranslated region of hTERT and decreases its expression (51). The level of miR-498 expression was decreased in malignant human ovarian tumor cells as well as in human ovarian cancer cell lines. The ability of vitamin D to decrease hTERT and to suppress ovarian cancer growth is reduced when miR-498 is depleted (51). However, all these studies were performed on cancer cell lines that are characterized by genomic instability, chromosome alterations and other features that are associated with transformed cells. Therefore, it is not possible to extrapolate the real role of vitamin D in telomere biology in healthy normal cells. From immunology point of view, Vitamin D has been known to have immunomodulatory effects on a wide range of immune cells including CD4+ and CD8+ lymphocytes, B lymphocytes, macrophages as well as dendritic cells (52), which are the main components of PBMCs. Several in vitro studies revealed that l,25(OH)2 D3 increases regulatory CD4+ T cell percentages and may reduce CD8+ T cell percentage (53). Moreover, there are differences in telomerase dynamics between CD4+ and CD8+ T cells. Therefore, we cannot exclude the possibility that vitamin D-induced increase in PBMC telomerase activity is due to the increase in certain cell types within the PBMC with higher telomerase activity since we did not sort the subtypes of PBMC at the time of collection and telomerase measurement. Further studies are needed to clarify the role of vitamin D in healthy cell's telomere biology.

Conclusions

In conclusion, it seems that existing evidence can nearly support the concept that vitamin D contributes to cellular aging and telomere biology. In human studies an inverse relationship between serum vitamin D and age-related diseases is shown as well as serum vitamin D and mortality. These studies are predominantly of cross-sectional nature and the included longitudinal and

interventional studies have been too small and heterogeneous to draw conclusive findings. Another limitation is the heterogeneity of studied population in age, gender and the type of morbidity. At a cellular level, vitamin D appears to regulate proliferation, senescence and apoptosis through genomic and non-genomic pathways like preservation of telomere biology. Animal and cell culture studies are also heterogeneous remarkably as they have used different animal models and cell types. This hampers the comparison of results and makes general conclusions impossible. Moreover, all studies published so far have significant limitations and results are sometimes conflicting. Further systematic studies are needed to understand the role of vitamin D in telomere biology and cellular aging.

References

1. G Aubert, PM Lansdorp Telomeres and Aging Physiological Reviews, 88 (2) (2008), pp. SS7-S79
2. I Pusceddu, L Farrell Christopher-John, M Di Pierro Angela, E Jani, WHerrmann, M Herrmann The role of telomeres and vitamin D in cellular aging and age-related diseases Clinical Chemistry and Laboratory Medicine (CCLM) (2015), p. 1661
3. MZ Levy, RC Allsopp, AB Futcher, CW Greider, CB Harley Telomere end-replication problem and cell aging Journal of Molecular Biology, 225 (4) (1992), pp. 951-960
4. CB Harley, AB Futcher, CW Greider Telomeres shorten during ageing of human fibroblasts Nature, 34S (1990), p. 4S8
5. J Zhang, G Rane, X Dai, MK Shanmugam, F Arfuso, RP Samy, MK Lai, DKappei, AP Kumar, G Sethi Ageing and the telomere connection: An intimate relationship with inflammation Ageing Res Rev, 25 (2016), pp. 55-69
6. Kord-Varkaneh H, Kord-Varkaneh H, Rinaldi G, Hekmatdoost A, Fatahi S, Tan SC, Shadnoush M, Khani V, Mousavi SM, Zarezadeh M. The influence of vitamin D supplementation on IGF-1 levels in humans: A systematic review and meta-analysis. 2020.
7. BN Ames Low micronutrient intake may accelerate the degenerative diseases of aging through allocation of scarce micronutrients by triage Proceedings of the National Academy of Sciences, 103 (47) (2006), pp. 17589-17594
8. Y-S Cong, WE Wright, JW Shay Human Telomerase and Its Regulation Microbiology and Molecular Biology Reviews, 66 (3) (2002), pp. 407-425
9. CB Harley, H Vaziri, CM Counter, RC Allsopp The telomere hypothesis of cellular aging Experimental Gerontology, 27 (4) (1992), pp. 375-382
10. AM Olovnikov A theory of marginotomy: The incomplete copying of template margin in enzymic synthesis of polynucleotides and biological significance of the phenomenon Journal of Theoretical Biology, 41 (l) (1973), pp. 181-190
11. EH Blackburn Structure and function of telomeres Nature, 350 (1991), p. 569
12. GB Morin Is Telomerase a Universal Cancer Target? JNCI: Journal of the National Cancer Institute, 87 (12) (1995), pp. 859-861
13. CW Greider, EH Blackburn Telomeres, telomerase and cancer Sci Am, 274 (2) (1996), pp. 92-97
14. LK Wai Telomeres, telomerase, and tumorigenesis—a review MedGenMed, 6 (3) (2004), p. 19
15. S Gravel, RJ Wellinger Maintenance of double-stranded telomeric repeats as the critical determinant for cell viability in yeast cells lacking Ku Mol Cell Biol, 22 (7) (2002), pp. 2182-2193
16. SS Chan, S Chang Defending the end zone: Studying the players involved in protecting chromosome ends FEBS Letters, 584 (17) (2010), pp. 3773-3778
17. H Zhu, S Shuman Gap filling activities of Pseudomonas DNA ligase D (LigD) polymerase and functional interactions of LigD with the DNA end-binding Ku protein J Biol Chem, 285 (7) (2010), pp. 4815-4825
18. WZ Mostafa, RA Hegazy Vitamin D and the skin: Focus on a complex relationship: A review J Adv Res, 6 (6) (2015), pp. 793-804
19. Z Lu, TC Chen, A Zhang, KS Persons, N Kohn, R Berkowitz, S Martinello, MFHolick An evaluation of the vitamin D3 content in fish: Is the vitamin D content adequate to satisfy the dietary requirement for vitamin D? J Steroid Biochem Mol Biol, 103 (3–5) (2007), pp. 642-644
20. M Chatterjea, R Shinde Textbook of Medical Biochemistry (Eighth Edition), Jaypee Brothers, Medical Publishers Pvt. Limited (2011)
21. AW Norman From vitamin D to hormone D: fundamentals of the vitamin D endocrine system essential for good health The American Journal of Clinical Nutrition, 88 (2) (2008), pp. 491S-499S
22. KD Cashman Vitamin D in childhood and adolescence Postgrad Med J, 83 (978) (2007), pp. 230-235
23. DD Bikle Vitamin D metabolism, mechanism of action, and clinical applications Chem Biol, 21 (3) (2014), pp. 319-329
24. B Matyjaszek-Matuszek, M Lenart-Lipinska, E Wozniakowska Clinical implications of vitamin D deficiency Prz Menopauzalny, 14 (2) (2015), pp. 75-81
25. EP Cherniack, BR Troen, HJ Florez, BA Roos, S Levis Some new food for thought: the role of vitamin D in the mental health of older adults Curr Psychiatry Rep, 11 (1) (2009), pp. 12-19
26. ET Jacobs, LN Kohler, AG Kunihiro, PW Jurutka Vitamin D and Colorectal, Breast, and Prostate Cancers: A Review of the Epidemiological Evidence J Cancer, 7 (3) (2016), pp. 232-240
27. Myhr K-M. Vitamin D treatment in multiple sclerosis2009. 104–8 p.
28. J McGrath, K Saari, H Hakko, J Jokelainen, P Jones, MR Jarvelin, D Chant, Misohanni Vitamin D supplementation during the first year of life and risk of schizophrenia: a Finnish birth cohort study Schizophr Res, 67 (2–3) (2004), pp. 237-245
29. N Salahuddin, F Ali, Z Hasan, N Rao, M Aqeel, F Mahmood Vitamin D accelerates clinical recovery from tuberculosis: results of the SUCCINCT Study [Supplementary Cholecalciferol in recovery from tuberculosis]. A randomized, placebo-controlled, clinical trial of vitamin D supplementation in patients with pulmonary tuberculosis' BMC Infectious Diseases, 13 (1) (2013), p. 22

30. M Herrmann, DR Sullivan, AS Veillard, T McCorquodale, TR Straub, R Scott, MLaakso, D Topliss, AJ Jenkins, S Blankenberg, *et al.* Serum 25-hydroxyvitamin D: a predictor of macrovascular and microvascular complications in patients with type 2 diabetes Diabetes Care, 38 (3) (2015), pp. 521-528

31. S Gandini, M Boniol, J Haukka, G Byrnes, B Cox, MJ Sneyd, P Mullie, P Autier Meta-analysis of observational studies of serum 25-hydroxyvitamin D levels and colorectal, breast and prostate cancer and colorectal adenoma Int J Cancer, 128 (6) (2011), pp. 1414-1424

32. DP Trivedi, R Doll, KT Khaw Effect of four monthly oral vitamin D3 (cholecalciferol) supplementation on fractures and mortality in men and women living in the community: randomised double blind controlled trial BMJ, 326 (7387) (2003), p. 469

33. JB Richards, AM Valdes, JP Gardner, D Paximadas, M Kimura, A Nessa, X Lu, GL Surdulescu, R Swaminathan, TD Spector, *et al.* Higher serum vitamin D concentrations are associated with longer leukocyte telomere length in women Am J ClinNutr, 86 (5) (2007), pp. 1420-1425

34. JJ Liu, J Prescott, E Giovannucci, SE Hankinson, B Rosner, J Han, I De Vivo Plasma vitamin D biomarkers and leukocyte telomere length Am J Epidemiol, 177 (12) (2013), pp. 1411-1417

35. PLoS One, 8 (5) (2013)

36. Matern Child Nutr, 14 (1) (2018)

37. H Lau, AF M.L, M Ludin, N Rajab, S Shahar Identification of Neuroprotective Factors Associated with Successful Ageing and Risk of Cognitive Impairment among Malaysia Older Adults Current Gerontology and Geriatrics Research, 2017 (2017), pp. 1-7

38. B Schottker, L Hagen, Y Zhang, X Gao, B Holleczek, X Gao, H Brenner Serum 25-Hydroxyvitamin D Levels as an Aging Marker: Strong Associations With Age and All-Cause Mortality Independent From Telomere Length, Epigenetic Age Acceleration, and 8-Isoprostane Levels J Gerontol A Biol Sei Med Sci, 74 (1) (2019), pp. 121-128

39. M Herlin, K Broberg, AM Igra, H Li, F Harari, M Vahter Exploring telomere length in mother-newborn pairs in relation to exposure to multiple toxic metals and potential modifying effects by nutritional factors BMC Med, 17 (1) (2019), p. 77

40. H Zhu, D Guo, K Li, J Pedersen-White, IS Stallmann-Jorgensen, Y Huang, SParikh, K Liu, Y Dong Increased telomerase activity and vitamin D supplementation in overweight African Americans Int J Obes (Lond), 36 (6) (2012), pp. 805-809

41. M Borras, S Panizo, F Sarro, JM Valdivielso, E Fernandez Assessment of the potential role of active vitamin D treatment in telomere length: a case-control study in hemodialysis patients ClinTher, 34 (4) (2012), pp. 849-856

42. C Siebert, TM Dos Santos, CG Berto, MM Parisi, RP Coelho, V Manfredini, FMBarbe-Tuana, ATS Wyse Vitamin D Supplementation Reverses DNA Damage and Telomeres Shortening Caused by Ovariectomy in Hippocampus of Wistar Rats NeurotoxRes, 34 (3) (2018), pp. 538-546

43. B Lanske, MS Razzaque Vitamin D and aging: old concepts and new insights J Nutr Biochem, 18 (12) (2007), pp. 771-777

44. Keisala T, Minasyan A, Lou Y-R, Zou J, Kalueff A, Pyykkö I, Tuohimaa P. Premature aging in vitamin D receptor mutant mice2009. 91–7 p.

45. Valcheva P, Cardus A, Panizo S, Parisi E, Bozic Stanojevic M, Lopez-Novoa J, Dusso A, Fernández E, Valdivielso J. Lack of vitamin D receptor causes stress-induced premature senescence in vascular smooth muscle cells through enhanced local angiotensin-II signals2014. 247–55 p.

46. T Nakatani, B Sarraj, M Ohnishi, MJ Densmore, T Taguchi, R Goetz, MMohammadi, B Lanske, MS Razzaque In vivo genetic evidence for klotho-dependent, fibroblast growth factor 23 (Fgf23) -mediated regulation of systemic phosphate homeostasis FASEB journal: official publication of the Federation of American Societies for Experimental Biology, 23 (2) (2009), pp. 433-441

47. B Lanske, MS Razzaque Premature aging in klotho mutant mice: cause or consequence? Ageing research reviews, 6 (l) (2007), pp. 73-79

48. CD Davis, JA Milner Nutrigenomics, vitamin D and cancer prevention J Nutrigenet Nutrigenomics, 4 (1) (2011), pp. 1-11

49. SN Kang, SH Kim, SW Chung, MH Lee, HJ Kim, TS Kim Enhancement of 1 alpha, 25-dihydroxyvitamin D(3)-induced differentiation of human leukaemia HL-60 cells into monocytes by parthenolide via inhibition of NF-kappa B activity British journal of pharmacology, 135 (5) (2002), pp. 1235-1244

50. N Ikeda, H Uemura, H Ishiguro, M Hori, M Hosaka, S Kyo, K Miyamoto, ETakeda, Y Kubota Combination treatment with lalpha,25-dihydroxyvitamin D3 and 9-cis-retinoic acid directly inhibits human telomerase reverse transcriptase transcription in prostate cancer cells Mol Cancer Ther, 2 (8) (2003), pp. 739-746

51. R Kasiappan, Z Shen, AKW Tse, U Jinwal, J Tang, P Lungchukiet, Y Sun, P Kruk, SV Nicosia, X Zhang, *et al.* 1,25-Dihydroxyvitamin D3 suppresses telomerase expression and human cancer growth through microRNA-498 The Journal of biological chemistry, 287 (49) (2012), pp. 41297-41309

52. U Querfeld Vitamin D and inflammation Pediatric Nephrology, 28 (4) (2013), pp. 605-610

53. S Gorman, S Geldenhuys, M Judge, C Weeden, J Waithman, P Hart Dietary Vitamin D Increases Percentages and Function of Regulatory T Cells in the Skin-Draining Lymph Nodes and Suppresses Dermal Inflammation Journal of Immunology Research, 2016 (2016), pp. 1-13

VITAMIN D AND AGING

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Abstract

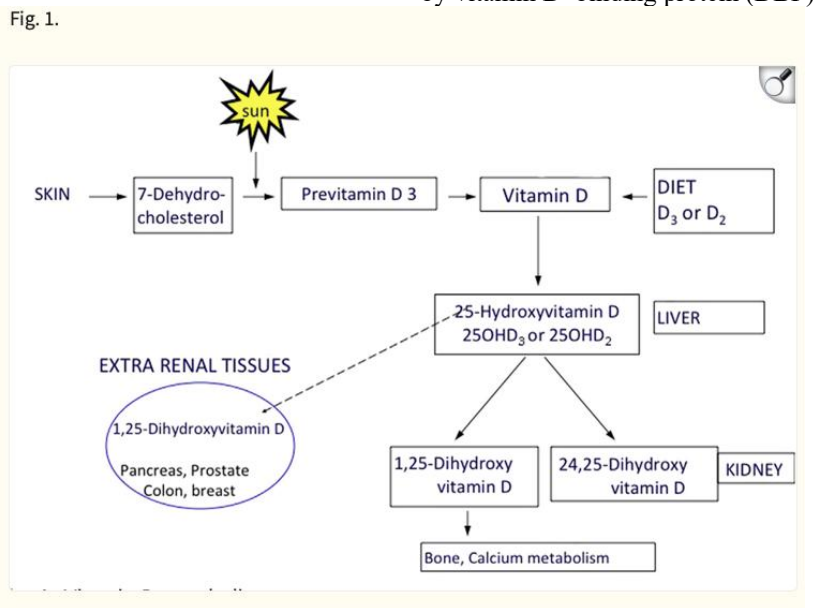
Aging affects the formation of 1,25-dihydroxyvitamin D (1,25[OH]2D; calcitriol), the active form of vitamin D. Production of 1,25(OH)2D is reduced by 50% as a result of an age-related decline in renal function, although serum 1,25(OH)2D levels are maintained in part by secondary hyperparathyroidism. Aging also causes a decrease in calcium absorption that precedes the decrease in 1,25(OH)2D by 10 to 15 years. Because 1,25(OH)2D is dependent on an adequate supply of the substrate vitamin D, the development of vitamin D deficiency leads to further reduction in the formation of 1,25(OH)2D. Measurement of the metabolite 25OHD provides the most widely used assessment of vitamin D deficiency. A serum 25OHD level lower than 10 ng/mL (25 nmol/L) represents vitamin D deficiency and leads to a reduction in serum 1,25(OH)2D. Vitamin D deficiency, is uncommon in North America, probably because of supplementation of dairy products and other foods with vitamin D. Sunlight exposure increases serum 25OHD levels by about 10 ng/mL during the months of April through September, resulting in low serum 25OHD for about 3 to 4 months in winter, with 2 additional months of low levels in more northern latitudes, such as Canada, and 2 fewer months in the southern states. Vitamin D supplementation in the winter can prevent vitamin D deficiency. Vitamin D insufficiency has been defined by the Institute of Medicine as a serum 25OHD level lower than 20 ng/mL (and >10 ng/mL). A serum 25OHD level lower than 20 ng/mL is associated with an increased fracture rate and increased rate of bone loss and treatment. Although other diseases have been associated with low serum 25OHD levels, the evidence for a causative role has not yet been established. Treatment of elderly people with vitamin D 800 IU daily will increase serum 25OHD levels to higher than 20 ng/mL and reduce fractures; this is particularly important in institutionalized people.

Keywords: Vitamin D metabolism, Aging, Vitamin D insufficiency, Vitamin D treatment.

Vitamin D metabolism

Vitamin D is derived from diet and sunlight and is not biologically active. Vitamin D must be sequentially converted into 25-hydroxyvitamin D (25OHD) in the liver by the enzyme CYP2R1 and then into 1,25-dihydroxyvitamin D (1,25[OH]2D) in the kidney by the CYP27B1 enzyme (1α hydroxylase) (Fig. 1). Both 1,25(OH)2D and 25OHD are carried in the circulation by vitamin D–binding protein (DBP).

Fig. 1.



The active hormonal form of vitamin D is 1,25(OH)2D, which binds to the vitamin D receptor (VDR) together with the retinoid X receptor to activate specific genes in target organs.1 VDR is present in many tissues besides bone, and certain cells, such as immune and osteoprogenitor cells, also contain the 1α hydroxylase enzyme as part of an intracrine and paracrine system. The regulation of the 1α hydroxylase enzyme is tightly maintained so as to keep serum 1,25(OH)2D levels constant. Production of 1,25(OH)2D is upregulated by parathyroid hormone (PTH) and low serum phosphorus and inhibited by fibroblast growth factor (FGF-23), which also regulates serum phosphorus levels. The enzyme CYP24 hydroxylase converts 25OHD to the nonactive metabolite 24,25(OH)2D in the kidney, thereby limiting the production of 1,25(OH)2D. Local formation of 24,25(OH)2D is also induced in many target tissues through negative feedback by 1,25(OH)2D.

1,25(OH)2D is essential for the efficient absorption of dietary calcium and phosphorus and for mineralization of bone. Recently, 1,25(OH)2D has been recognized to have a multitude of other biologic functions. Studies suggest that it is unlikely that serum 25OHD has an independent physiologic function that is not fulfilled by 1,25(OH)2D.

Effect of age and vitamin D on calcium metabolism

The following are effects of age on vitamin D and calcium metabolism:

- Decreased calcium absorption
- Intestinal resistance of calcium absorption to circulating 1,25(OH)2D
- Decreased VDR
- Decreased renal production of 1,25(OH)2D by the aging kidney
- Decreased skin production of vitamin D
- Substrate deficiency of vitamin D

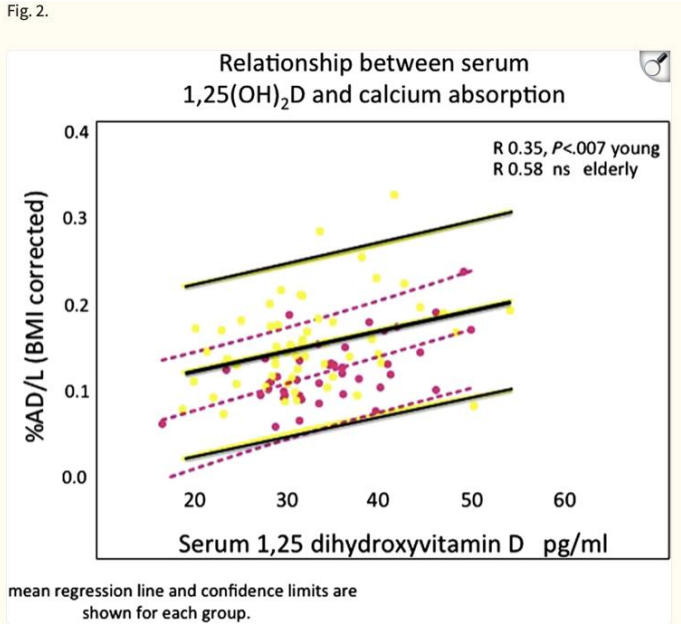
Decreased Calcium Absorption

Malabsorption of calcium occurs as part of aging and starts at approximately age 65 to 70 years.2,3 As a result, it leads to negative calcium balance, secondary hyperparathyroidism, increased bone loss, and osteoporosis. Because of malabsorption of calcium, there is a decreased ability to adapt to a low-calcium diet by increasing fractional calcium absorption.4 Although several independent dietary factors affect calcium absorption, such as protein intake, sodium intake, or glucose, the main regulator is 1,25(OH)2D acting through the VDR and synthesizing genes and proteins involved in calcium transport.5Deletion of the VDR results in malabsorption of calcium.6 Calcium absorption occurs by both an active saturable system and a passive diffusion transport system. Active transport of calcium occurs through transcellular and paracellular pathways in the duodenum and jejunum, whereas passive paracellular absorption is the main process of calcium absorption throughout the intestine.7 At the molecular level, the calcium-binding protein calbindin-D9kand an epithelial calcium channel transient receptor potential vanilloid type 6 (TRPV6) were initially thought to mediate the diffusion of calcium across the gut.7–9 However, in TRPV6/Calbindin-D9k double knockout mice, calcium absorption still responds to 1,25(OH)2D administration, challenging this mechanism.10 The tight junction proteins Claudins-2 and Claudins-12 facilitate paracellular calcium transport and are upregulated by 1,25(OH)2D via the VDR receptor.11 In summary, part of the change in calcium absorption with aging may be because of abnormalities in the transport proteins that are regulated by 1,25(OH)2D.

Intestinal Resistance of Calcium Absorption to Circulating 1,25(OH)2D

In young healthy people, there is a positive correlation between calcium absorption and serum 1,25(OH)2D, but in older people and patients with osteoporosis, the calcium absorption response is lower relative to serum 1,25(OH)2D than in young people (Fig. 2), suggesting intestinal resistance to endogenous circulating 1,25(OH)2D.12,13 However, administration of a small oral dose of calcitriol 0.25 μg twice daily to elderly people completely normalizes malabsorption of calcium, suggesting that calcitriol may have a first-pass effect on intestinal transport.14

Fig. 2.



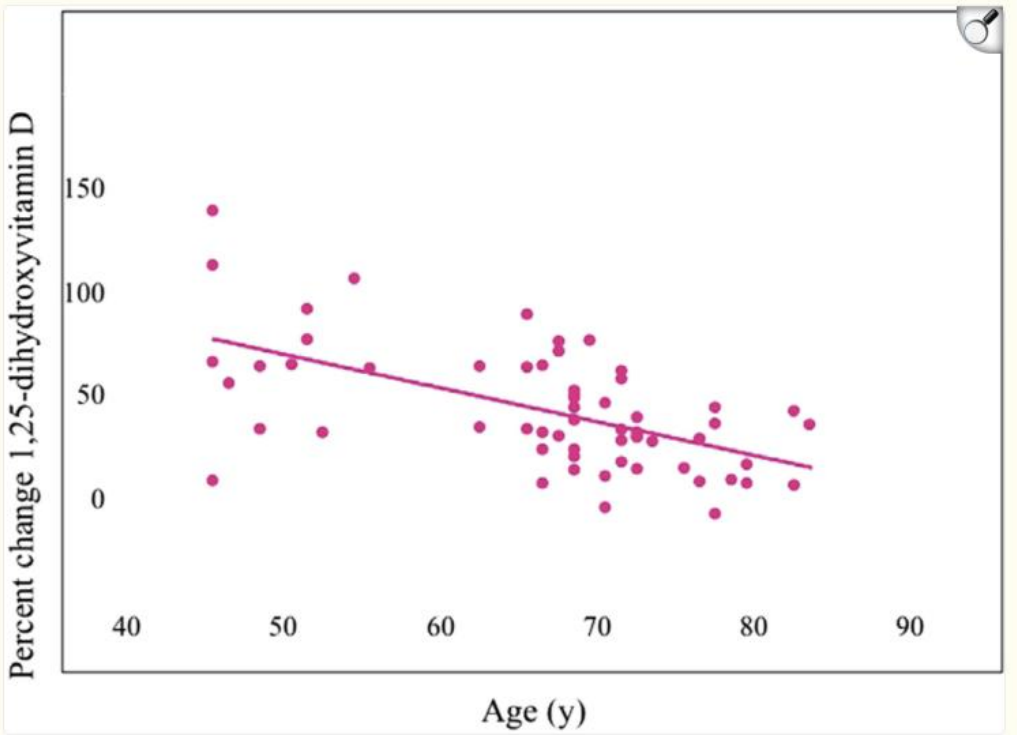
Decreased VDR

Aging may affect the intestinal concentration of VDR to cause a decrease in calcium absorption, as demonstrated in aging rats.15 There have been 2 studies of intestinal VDR performed on biopsies in humans. A small study of 9 subjects older than 65 years Vitamin D and Aging 321 showed a decrease in intestinal VDR concentration with age but no change in serum 1,25(OH)2D.16 In a similar study of 41 women older than 65, 10 of whom were older than 75, there was no difference in intestinal VDR concentration compared with 59 women younger than 35.17

Decreased Renal Production of 1,25(OH)2D by the Aging Kidney

As renal function declines with age, there is a decrease in the activity of the renal enzyme 1α hydroxylase that converts 25OHD into 1,25(OH)2D. Serum 1,25(OH)2D levels are inversely related to serum creatinine and glomerular function rate (GFR) and a GFR of 50 mL/min is a level that affects 1,25(OH)2D production.18 Because many people older than 80 have a GFR less than 50 mL/min, decreased production of 1,25(OH)2D in this age group is common. To examine the effect of age and GFR on the 25OHD-1,25(OH)2D axis, we infused PTH for 24 hours in women of different ages. The increase in serum 1,25(OH)2D was about 50% lower in the older subjects, indicating decreased renal responsiveness to PTH with age (Fig. 3).19

Fig. 3.



Measurement of serum 1,25(OH)2D in elderly people shows the impact clinically of declining renal production. In a study of women aged 80 to 95 years who were residents of nursing homes and had normal 25OHD levels, the serum 1,25(OH)2D levels were much lower than in women aged 65 to 75 years (Fig. 4). In summary,

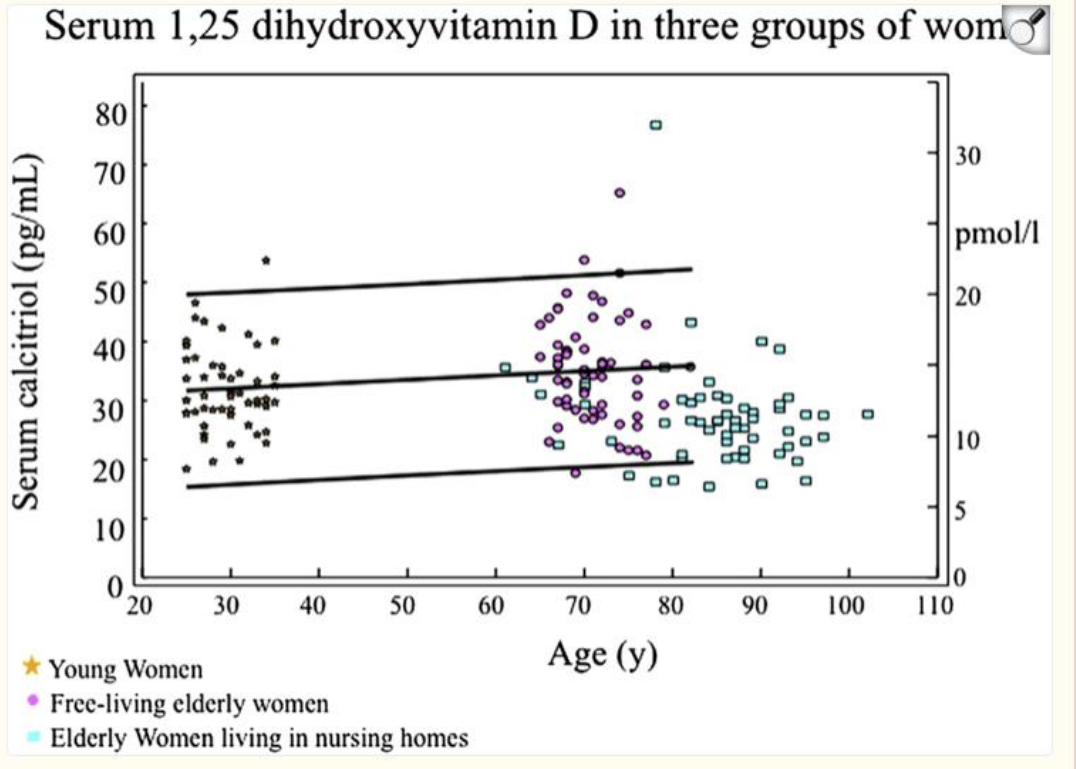
There is an age-related decrease in calcium absorption that is partly dependent and partly independent of 1,25(OH)2D.

Serum 1,25(OH)2D levels decrease as a result of an age-related decline in renal function.

Reduced levels of serum 1,25(OH)2D likely further reduce calcium absorption, causing secondary hyperparathyroidism and increased bone resorption.

Secondary hyperparathyroidism persistently stimulates renal 1,25(OH)2D production until the kidney can no longer respond effectively.

Fig. 4.



Decreased Skin Production

Aging reduces vitamin D production in skin. There is a decrease in the concentration of 7-dehydrocholesterol in the epidermis in old compared with young individuals and a reduced response to UV light, resulting in a 50% decrease in the formation of previtamin D3.20

Substrate Deficiency of Vitamin D

All age-related changes in vitamin D metabolism are magnified if there is concomitant vitamin D deficiency, because it limits the substrate supply for 25OHD and ultimately 1,25(OH)2D. Substrate deficiency is a common problem in the elderly and is important to recognize because it is preventable and treatable. There may be deficiency of vitamin D either from diet or from lack of sunlight, and the decrease in serum 25OHD further limits 1,25(OH)2D production, especially when there is also renal dysfunction. Serum 1,25(OH)2D levels decrease when serum the 25OHD level falls below 10 ng/mL in both younger21 and older22 people.

Vitamin D nutrition in the elderly

Vitamin D is a unique nutrient because its requirement is met from diet and skin. The dietary intake of vitamin D can be estimated from dietary food tables and is usually between 100 and 400 IU daily. Dietary surveys in North America in the National Health and Nutrition Examination Survey (NHANES) show that dietary intake of vitamin D is low, averaging 200 IU daily (Table 1), and, unless one eats a lot of fish with high vitamin D content, daily intake is unlikely to exceed 400 IU daily. Vitamin D intake increases with age because elderly people consume more multivitamins that contain vitamin D.23,24

Table 1.

Vitamin D intake and serum 25 hydroxyvitamin D (25OHD) for the United States, 2005–2006

Age Group (y)	Vitamin D Intake (IU/d) (mean ± SE)		Serum 25OHD ng/mL (mean ± SE)
	Diet Alone[a]	Total Intake[b]	
Males			
14–18	244 ± 16	276 ± 20	24 ± 0.6
19–30	204 ± 12	264 ± 16	23 ± 0.5
31–50	216 ± 12	316 ± 12	24 ± 0.4
51–70	204 ± 12	352 ± 16	24 ± 0.5
>70	224 ± 16	428 ± 28	24 ± 0.4
Females			
14–18	152 ± 8	200 ± 20	24 ± 0.7
19–30	144 ± 12	232 ± 12	25 ± 0.8
31–50	176 ± 12	308 ± 20	23 ± 0.5
51–70	156 ± 16	404 ± 40	23 ± 0.4
>70	180 ± 8	400 ± 20	23 ± 0.4

The production of vitamin D in skin cannot be measured directly; however, the change in serum 25OHD gives an estimate of the effect of sun if diet remains constant. In the Midwest at latitude 40°, serum 25OHD increases by 50% from 20 to 30 ng/mL in summer25; this change is equivalent to a daily oral vitamin D dose of 2000 IU daily. The UV spectrum is effective only when the sun is more than 30° above the horizon. Below that level, ground pollution filters out the UV rays. In the Midwestern section of North America, effective UV light occurs only between late April and early September. Effective UV exposure time is 2 months less in Canada and 2 months more in Florida. Vitamin D supplementation should be increased in winter.

SUMMARY

Age-related changes affect vitamin D metabolism and reduce the nutritional status of the elderly. A vitamin D supplement is recommended in the elderly. The optimal total calcium intake is unclear. In the absence of adequate safety data, it is suggested that total calcium intake be limited to 1000 to 1200 mg daily, because of a 35% incidence of hypercalciuria or hypercalcemia in women taking low doses of vitamin D who have a total calcium intake of 1200 mg daily.39 Increasing calcium from dietary sources may be safer than supplements, and requires increasing the intake of dairy products or other vitamin D and calcium-fortified foods. The RDA value is listed on every food and vitamin either as the actual amount or as a percentage of the RDA. For example, if the RDA for vitamin D is 800 IU and a multivitamin contains 1000 IU, the multivitamin provides 125% of the RDA. It has been common practice to supplement dairy products in the United States, Canada, and Scandinavian countries. In North America, milk is fortified with 400 IU per quart. An 8-oz glass of milk provides 80 IU of vitamin D and 250 mg calcium. Evidence suggests that vitamin D and calcium nutrition can be improved in the elderly by increasing the vitamin D intake to 800 IU daily together with calcium 1000 mg daily. This combination is a simple inexpensive strategy that can reduce fractures in institutionalized individuals by 30%.

References

1. DeLuca HF. Overview of general physiologic features and functions of vitamin D. Am J Clin Nutr. 2004;80:1689S–1996S. doi: 10.1093/ajcn/80.6.1689S.

2. Bullamore JR, Gallagher JC, Wilkinson R, et al. Effect of age on calcium absorption. Lancet. 1970;II:535–537. doi: 10.1016/s0140-6736(70)91344-9.

3. Ireland P, Fordtran JS. Effect of dietary calcium and age on jejunal calcium absorption in human studies by intestinal perfusion. J Clin Invest. 1973;52:2672–2681. doi: 10.1172/JCI107461.

4. Gallagher JC, Riggs BL, Eisman J, et al. Intestinal calcium absorption and serum vitamin D metabolites in normal subjects and osteoporotic patients. J Clin Invest. 1979;64:729–736. doi: 10.1172/JCI109516.

5. Pike JW. Vitamin D3 receptors: structure and function in transcription. Annu Rev Nutr. 1991;11:189–216.

6. Li YC, Pirro AE, Amling M, et al. Targeted ablation of the vitamin D receptor: an animal model of vitamin D-dependent rickets type II with alopecia. Proc Natl Acad Sci U S A. 1997;94:9831–9835. doi: 10.1073/pnas.94.18.9831.

7. Sheikh MS, Ramirez A, Emmett M, et al. Role of vitamin D dependent and vitamin D independent mechanisms in absorption of food calcium. J Clin Invest. 1988;81:126–132. doi: 10.1172/JCI113283.

8. Akhter S, Kutuzova GD, Christakos S, et al. Calbindin D9k is not required for 1,25-dihydroxyvitamin D3-mediated Ca21 absorption in small intestine.

Arch Biochem Biophys. 2007;460(2):227–232. doi: 10.1016/j.abb.2006.12.005.

9. Kutuzova GD, Sundersingh F, Vaughan J, et al. TRPV6 is not required for 1alpha,25-dihydroxyvitamin D3-induced intestinal calcium absorption in vivo. Proc Natl Acad Sci U S A. 2008;105(50):19655–19659. doi: 10.1073/pnas.0810761105.

10. Benn BS, Ajibade D, Porta A, et al. Active intestinal calcium transport in the absence of transient receptor potential vanilloid type 6 and calbindin-D9k. Endocrinology. 2008;149(6):3196–3205. doi: 10.1210/en.2007-1655.

11. Fujita H, Sugimoto K, Inatomi S, et al. Tight junction proteins claudin-2 and-12 are critical for vitamin D-dependent Ca21 absorption between enterocytes. Mol Biol Cell. 2008;19(5):1912–1921. doi: 10.1091/mbc.E07-09-0973.

12. Francis RM, Peacock M, Taylor GA, et al. Calcium malabsorption in elderly women with vertebral fractures: evidence for resistance to the action of vitamin D metabolites on the bowel. Clin Sci (Lond) 1984;66:103–107. doi: 10.1042/cs0660103.

13. Kinyamu HK, Gallagher JC, Balhorn KE, et al. Serum vitamin D metabolites and calcium absorption in normal and elderly free-living women and in women in nursing homes. Am J Clin Nutr. 1997;65:790–797. doi: 10.1093/ajcn/65.3.790

14. Gallagher JC, Jerpbak CM, Jee WS, et al. 1,25-Dihydroxyvitamin D3: short- and long-term effects on bone and calcium metabolism in patients with postmenopausal osteoporosis. Proc Natl Acad Sci U S A. 1982;79(10):3325. doi: 10.1073/pnas.79.10.3325.

15. Horst RL, Goff JP, Reinhardt TA. Advancing age results in reduction of intestinal and bone 1,25-dihydroxyvitamin D receptor. Endocrinology. 1990;126:1053–1057. doi: 10.1210/endo-126-2-1053.

16. Ebeling PR, Sandgren ME, DiMagno EP, et al. Evidence of an age-related decrease in intestinal responsiveness to vitamin D: relationship between serum 1,25-dihydroxyvitamin D3 and intestinal vitamin D receptor concentrations in normal women. J Clin Endocrinol Metab. 1992;75:176–182. doi: 10.1210/jcem.75.1.1320048.

17. Kinyamu HK, Gallagher JC, Prahl JM, et al. Association between intestinal vitamin D receptor, calcium absorption, and serum 1,25 dihydroxyvitamin D in normal young and elderly women. J Bone Miner Res. 1996;11:1400–1405. doi: 10.1359/jbmr.1997.12.6.922.

18. Tsai KS, Heath H, III, Kumar R, et al. Impaired vitamin D metabolism with aging in women. Possible role in pathogenesis of senile osteoporosis. J Clin Invest. 1984;73:1668–1672. doi: 10.1172/JCI111373.

19. Kinyamu HK, Gallagher JC, Petranick KM, et al. Effect of parathyroid hormone (hPTH[1-34]) infusion on serum 1,25-dihydroxyvitamin D and parathyroid hormone in normal women. J Bone Miner Res. 1996;11(10):1400–1405. doi: 10.1002/jbmr.5650111005.

20. MacLaughlin J, Holick MF. Aging decreases the capacity of human skin to produce vitamin D3. J Clin Invest. 1985;76:1536–1538. doi: 10.1172/JCI112134.

21. Bouillon RA, Auwerx JH, Lissens WD, et al. Vitamin D status in the elderly: seasonal substrate deficiency causes 1,25-dihydroxycholecalciferol deficiency. Am J Clin Nutr. 1987;45:755–763. doi: 10.1093/ajcn/45.4.755.

22. Need AG, O'Loughlin PD, Morris HA, et al. Vitamin D metabolites and calcium absorption in severe vitamin D deficiency. J Bone Miner Res. 2008;23:1859–1863. doi: 10.1359/jbmr.080607.

23. Bailey RL, Dodd KW, Goldman JA, et al. Estimation of total usual calcium and vitamin D intakes in the United States. J Nutr. 2010;140(4):817–822. doi: 10.3945/jn.109.118539.

24. Institute of Medicine. Dietary reference intakes for calcium and vitamin D. Washington, DC: The National Academies Press; 2011. Available at: http://www.ncbi.nlm.nih.gov/books/NBK56072.

25. Rapuri PB, Kinyamu HK, Gallagher JC, et al. Seasonal changes in calciotropic hormones, bone markers, and bone mineral density in elderly women. J Clin Endocrinol Metab. 2002;87:2024–2032. doi: 10.1210/jcem.87.5.8475.

26. Prevention and management of osteoporosis: report of a WHO scientific group. Geneva (Switzerland): World Health Organization; 2003. WHO Scientific Group on the Prevention and Management of Osteoporosis.

27. Holick MF, Binkley NC, Bischoff-Ferrari HA, et al. Evaluation, treatment, and prevention of vitamin D deficiency: an Endocrine Society clinical practice guideline. J Clin Endocrinol Metab. 2011;96:1911–1930. doi: 10.1210/jc.2011-0385.

28. Looker AC, Johnson CL, Lacher DA, et al. NCHS data brief, no 59. Hyattsville (MD): National Center for Health Statistics; 2011. Vitamin D status: United States (2001– 2006)

29. Taylor CL, Carriquiry AL, Bailey RL, et al. Appropriateness of the probability approach with a nutrient status biomarker to assess population inadequacy: a study using vitamin D. Am J Clin Nutr. 2012;97(1):72–78. doi: 10.3945/ajcn.112.046094.

30. Bruyere O, Decock C, Delhez M, et al. Highest prevalence of vitamin D inadequacy in institutionalized women compared with non-institutionalized women: a case–control study. Womens Health (Lond Engl) 2009;5(1):49–54. doi: 10.2217/17455057.5.1.49.

31. Cashman KD, Muldowney S, McNulty B, et al. Vitamin D status of Irish adults: findings from the National Adult Nutrition Survey. Br J Nutr. 2012;10:1–9. doi: 10.1017/S0007114512003212.

32. Gaugris S, Heaney RP, Boonen S, et al. Vitamin D inadequacy among post-menopausal women: a systematic review. QJM. 2005;98(9):667–676. doi: 10.1093/qjmed/hci096.

33. Glerup H, Mikkelsen K, Poulsen L, et al. Commonly recommended daily intake of vitamin D is not sufficient if sunlight exposure is limited. J Intern Med. 2000;247:260–268. doi: 10.1046/j.1365-2796.2000.00595.x.

PEDAGOGICAL SCIENCES

TRANSPARENCY OF ASSESSMENT CRITERIA AND ITS EFFECT ON MOTIVATION

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Abstract
The modern higher education system is undergoing profound structural changes that affect not only organisational models of learning, but also internal mechanisms for shaping students' professional motivation. Technological developments, the digitisation of the educational process and the need to adapt to a rapidly changing labour market are leading to a rethinking of traditional approaches to education and making issues of motivation particularly relevant. Among the tools capable of effectively supporting and developing internal motivation for learning, the Pedagogical Monitoring and Assessment System (PMAS) stands out, becoming not only a mechanism of administrative control, but also a psychological tool that influences the behaviour, self-esteem and professional development of future specialists.
Keywords: professional motivation, pedagogical monitoring, approach, assessment system, meta-subject competence.

Professional motivation among students is traditionally viewed as a complex system of internal and external factors that encourage students to actively participate in the learning process, strive for self-improvement, and achieve professional goals. Motivation can be influenced by various factors: interest in the profession, social expectations, career prospects, personal values, material incentives, the educational environment, and pedagogical interaction. However, in the context of modernising education, the influence of objective and transparent mechanisms for assessing academic performance, which involve not only testing knowledge but also monitoring the dynamics of competence development, is of particular importance. That is why, the Pedagogical Monitoring and Assessment System is becoming a key tool influencing the formation of professional motivation and a conscious attitude of students towards learning.

One of the most important aspects of studying motivation is understanding how regular assessment and feedback affect students' perceptions of their own success. Psychological research shows that motivation increases when students see the real dynamics of their success and understand what specific actions have led to improved results. The Pedagogical Monitoring and Assessment System provides an opportunity to record such changes through the systematic collection of data on the development of skills, knowledge and competencies, which allows students to recognise their successes and adjust their learning strategies. In this way, the monitoring system stimulates intrinsic motivation by promoting reflection, self-analysis and self-regulation. This aspect is particularly important in the context of vocational education, where the ability to independently assess one's achievements is a key competence for future professionals.

In addition, professional motivation is enhanced when students understand the practical significance of the learning material and its relevance to their future professional activities. In the traditional model of education, assessment was often formal in nature and did not always reflect the student's actual level of readiness to perform professional tasks. The Pedagogical Monitoring and Assessment System, on the other hand, is based on a competency-based approach, according to which not only knowledge is assessed, but also the ability to apply it in practice, communication skills and the ability to independently resolve professional situations. This form of assessment is more meaningful for students because they see a direct link between their academic achievements and employment. Awareness of the practical value of knowledge and skills directly influences internal motivation, increases interest in studying the material, and contributes to the formation of professional identity.

However, the impact of the Pedagogical Monitoring and Assessment System on motivation is not entirely positive. In some cases, excessive focus on assessment can lead to a decline in intrinsic motivation and its replacement by external incentives. When students begin to perceive monitoring as a tool for pressure or punishment rather than a means for development, they may experience anxiety, stress, and avoidance of challenging tasks. It is therefore important to ensure competent pedagogical support for the Pedagogical Monitoring and Assessment System, which involves an emphasis on supportive feedback, recognition of student effort, and encouragement of initiative and independence. Only such a monitoring model promotes the development of achievement motivation rather than avoidance motivation. It is important that the teacher is not only an expert in the subject area, but also a psychologically competent mentor who can create conditions for safe learning, minimise fear of failure and support the desire for self-improvement.

Transparency of assessment criteria is also very important. If students clearly understand what knowledge and skills are being assessed, what requirements are being set, and what indicators are considered

successful, their motivation becomes more stable. Uncertainty, on the contrary, causes anxiety and reduces activity in learning. As a structured system, the Pedagogical Monitoring and Assessment System involves clearly defining criteria, indicators, and achievement levels, which makes the assessment process understandable and predictable for students. This approach helps to build lasting motivation to learn, as students feel that their success depends on their own efforts rather than on the subjective decisions of teachers. In addition, the transparency of the criteria increases trust in the teacher and the education system as a whole, reinforces a sense of fairness and encourages honest, responsible completion of learning tasks.

Another important factor is the possibility of using the Pedagogical Monitoring and Assessment System as a tool for individualising learning. Since the system records not only the final results but also the dynamics of development, teachers can adjust learning trajectories, differentiate tasks and take into account the individual characteristics of students. This is especially important in vocational education, where students often have different levels of preparation and different educational needs. An individualised approach helps to increase motivation, as students feel that their efforts are recognised, receive assignments appropriate to their level, and see the real benefits of their work. The ability to independently plan and adjust the learning process gives students a sense of autonomy, strengthens their intrinsic interest, and develops self-regulation skills that are in demand in professional activities.

It is also important to note the impact of the Pedagogical Monitoring and Assessment System on the development of meta-subject competencies, which play a significant role in the formation of professional motivation. These include skills such as critical thinking, self-assessment, planning, analysing one's own achievements and mistakes, setting goals and learning strategies. By integrating regular reflection, teaching how to work with monitoring results and the ability to interpret data, the Pedagogical Monitoring and Assessment System contributes to the development of these competencies. As a result, students begin to perceive their learning activities as a systematic process in which they are active participants rather than passive performers of tasks. Metacognitive skills enable them to transfer their learning experiences and strategies to new situations, which is an important component of professional competence.

From a pedagogical point of view, it is important that the Pedagogical Monitoring and Assessment System contributes to the humanisation of the educational process. The system is not limited to recording mistakes, but is focused on support and development. It creates conditions for partnership between teacher and student, where assessment is perceived as a tool for growth rather than a sanction. This atmosphere of trust and cooperation has a significant impact on professional motivation, as students feel safe, respected and supported, which contributes to the formation of a positive attitude towards the learning process. This aspect is especially important in the early stages of learning a subject, when students feel uncertain about their knowledge and skills.

At the same time, the introduction of the Pedagogical Monitoring and Assessment System requires a certain culture of pedagogical assessment, teachers' readiness for objectivity and the use of monitoring data for development purposes, rather than for exerting pressure. When monitoring becomes a formality or is used exclusively for control, the motivational effect not only disappears, but can also become negative. Therefore, the key task is to ensure that, the Pedagogical Monitoring and Assessment System functions as a system for development rather than punishment. This requires training teachers to work with the system, developing constructive feedback skills, and the ability to identify individual achievements and support the development of students with different levels of preparation.

It should be emphasised that the successful use of the Pedagogical Monitoring and Assessment System is directly linked to the integration of various pedagogical and psychological approaches. The theory of activity developed by L. S. Vygotsky and A. N. Leontiev emphasises that any educational activity must be motivated, purposeful and conscious. PMSA creates conditions for the implementation of these principles: students see the purpose of their actions, understand the connection between effort and results, and receive information about their successes and areas requiring attention. This is especially important in the context of developing professional motivation, as future specialists learn to recognise the significance of each learning task for their professional training.

In addition, the Pedagogical Monitoring and Assessment System promotes the development of self-regulation skills, which include planning, monitoring and evaluating one's own learning activities. Systematic monitoring allows students to develop a strategy for mastering the material, adjust their working methods, analyse mistakes and evaluate their achievements. This process promotes the formation of internal responsibility for results and increases motivation. Self-regulation and internal motivation are interrelated: the greater a student's ability to control their activities, the more sustainable their desire to achieve goals becomes and the higher the quality of their learning. Within the framework of the Pedagogical Monitoring and Assessment System, special attention is paid to a functional and activity-oriented approach to learning. Studying disciplines based on conscious practical activity allows students not only to memorise facts, but also to apply them in specific professional situations. Developing skills through practical application of the material increases the relevance of learning for students, which enhances their motivation. Thus, completing projects related to real professional tasks, participating in simulation situations, and modelling practical processes contribute to the development of competencies, self-confidence, and professional identity.

The Pedagogical Monitoring and Assessment System is also closely linked to the concept of a competency-based approach, which is becoming the foundation of modern higher education. The competency-based approach aims to develop students' ability to act effectively in their professional field, integrate knowledge and skills, make decisions, and evaluate the

results of their activities. Professional motivation is enhanced when students see that mastering the course material is directly related to the development of the competencies required in their future profession. This approach contributes to the formation of conscious motivation and creates conditions for long-term professional development.

Thus, PMSA performs several interrelated functions: it ensures control of knowledge and skills, promotes the development of meta-subject competencies, stimulates internal motivation, supports reflection and self-regulation, contributes to the humanisation of the educational process and the integration of a competency-based approach. Together, these elements form a sustainable system of support for students' professional motivation, making the educational process more meaningful, structured, and focused on personal and professional development.

In conclusion, it should be noted that the effectiveness of the Pedagogical Monitoring and Assessment System in the context of professional motivation formation is determined by a comprehensive approach to the organisation of the educational process. Only the comprehensive use of monitoring tools, transparent assessment criteria, a differentiated approach to students, supportive feedback, and integration with activity- and competence-based approaches can ensure sustainable internal motivation, the development of professional identity, and competencies. In the context of modern higher education, which is focused on the quality of training specialists and their readiness for professional self-realisation, PMSA is becoming an indispensable tool for shaping motivated, competent and professionally trained graduates.

References

1. Efendieva S. //Formation of positive motivation for learning English among medical students at the UMSA Higher Educational Institution. Science and Education a New Dimension. Pedagogy and Psychology. 2018. VI (64). Issue 154. P. 26–29.

2. Didenko M. //Features of creating situations of success in English classes at universities. Scientific Notes of the National University "Ostrog Academy". Series: Philological. 2016. No. 62. P. 117–119.

3. Gilyun O. //Educational motivations of student youth. Grani. 2012. No. 1 (81). Pp. 102–104.

4. Mykhailichenko V. //The role of motivation in educational and cognitive activities in shaping students' professional orientation. Pedagogy of creative personality formation in higher and general education schools. 2011. Issue 17 (70). Pp. 320–327.

5. Kholmakova, Yu. //Motivation for learning foreign languages as a phenomenon of modern science and practice. Young Scientist. 2016. No. 4.1. Pp. 103–105. URL: http://nbuv.gov.ua/UJRN/molv_2016_4.1_30.

6. Lobachova I. //The motivational aspect in teaching English to future specialists. Professionalism of teachers in the context of educational innovations: monograph. Hameln, Germany: InterGING, 2018. Pp. 70–80.

ПЕДАГОГИЧЕСКИЕ УСЛОВИЯ СОВЕРШЕНСТВОВАНИЯ ПРОФЕССИОНАЛЬНОЙ ПОДГОТОВКИ БУДЩЕГО УЧИТЕЛЯ МУЗЫКИ В КОНТЕКСТЕ ЦИФРОВИЗАЦИИ ОБРАЗОВАНИЯ

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PEDAGOGICAL CONDITIONS FOR IMPROVING THE PROFESSIONAL TRAINING OF FUTURE MUSIC TEACHERS IN THE CONTEXT OF THE DIGITALIZATION OF EDUCATION

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Аннотация

В статье рассматриваются педагогические условия совершенствования профессиональной подготовки будущего учителя музыки в контексте цифровизации образования. Актуальность исследования обусловлена необходимостью адаптации системы педагогического образования к современным цифровым требованиям, а также формированием у будущих педагогов профессиональных компетенций, обеспечивающих эффективное использование цифровых технологий в музыкально-педагогической деятельности. Цель исследования заключается в выявлении и теоретическом обосновании педагогических условий, способствующих повышению качества профессиональной подготовки будущих учителей музыки в условиях цифровой образовательной среды. В работе образовательный процесс подготовки рассматривается как комплексная система, включающая содержательные, организационно-методические и технологические компоненты. В рамках исследования проанализированы современные научные подходы к проблеме цифровизации образования и профессиональной подготовки педагогов, уточнено содержание понятия «цифровая образовательная среда», а также определены ключевые педагогические условия, обеспечивающие эффективность подготовки будущих учителей музыки.

Результаты исследования показывают, что интеграция цифровых образовательных ресурсов, использование интерактивных и мультимедийных технологий, развитие цифровой педагогической компетентности, а также создание условий для творческой самореализации студентов способствуют повышению уровня их профессиональной готовности и формированию устойчивой мотивации к педагогической деятельности.

Abstract

The article examines the pedagogical conditions for improving the professional training of future music teachers in the context of the digitalization of education. The relevance of the study is обусловлена the need to adapt the system of teacher education to modern digital requirements, as well as to develop professional competencies that enable future educators to effectively use digital technologies in music pedagogical practice. The purpose of the study is to identify and theoretically substantiate the pedagogical conditions that contribute to enhancing the quality of professional training of future music teachers within a digital educational environment. The training process is considered as a comprehensive system that includes content-related, organizational-methodological, and technological components. The study analyzes contemporary scientific approaches to the issues of digitalization in education and teacher training, clarifies the concept of a “digital educational environment,” and identifies key pedagogical conditions that ensure effective training of future music teachers. The results indicate that the integration of digital educational resources, the use of interactive and multimedia technologies, the development of digital pedagogical competence, and the creation of conditions for students’ creative self-realization contribute to improving their professional readiness and fostering sustainable motivation for teaching activities.

Ключевые слова: Профессиональная подготовка, будущий учитель музыки, цифровизация образования, цифровая образовательная среда, педагогические условия, цифровая компетентность, музыкально-педагогическое образование, интерактивные технологии обучения.

Keywords: Professional training, future music teacher, digitalization of education, digital educational environment, pedagogical conditions, digital competence, music teacher education, interactive learning technologies.

Введение

Современная система педагогического образования переживает этап активной трансформации, обусловленной процессами цифровизации и внедрения инновационных технологий в образовательную практику. В этих условиях особую значимость приобретает подготовка будущих учителей музыки, способных эффективно осуществлять профессиональную деятельность в цифровой образовательной среде, интегрируя традиционные и современные формы обучения. Это обуславливает необходимость поиска и научного обоснования

педагогических условий, обеспечивающих повышение качества их профессиональной подготовки.

Несмотря на возрастающий интерес к проблемам цифровизации образования и подготовки педагогических кадров, большинство исследований сосредоточено на формировании отдельных цифровых компетенций или использовании информационных технологий в образовательном процессе. Вместе с тем недостаточно изученными остаются вопросы комплексного обеспечения педагогических условий, способствующих целостному совершенствованию профессиональной подготовки будущего учителя музыки с учётом специфики музыкально-педагогической деятельности.

Целью данной работы является выявление и теоретическое обоснование педагогических условий совершенствования профессиональной подготовки будущего учителя музыки в контексте цифровизации образования. Для достижения поставленной цели предполагается решение следующих задач: раскрыть сущность понятий «профессиональная подготовка будущего учителя музыки», «цифровая образовательная среда» и «педагогические условия»; проанализировать современные теоретические подходы к проблеме цифровизации педагогического образования; определить ключевые педагогические условия, способствующие повышению качества подготовки будущих учителей музыки.

Теоретические основания исследования педагогических условий совершенствования профессиональной подготовки будущего учителя музыки в контексте цифровизации образования.

Особенность профессиональной подготовки учителя музыки заключается в многомерности развиваемых компетенций: предметно-методических, музыкальных (инструментальных, теоретико-композиторских), психологических и коммуникативных, а также творческих навыков, которые требуют специфических форм организации образовательной среды [1]. Учитель музыки должен владеть не только профессиональным содержанием предмета, но и способностью интегрировать современные образовательные технологии в практику обучения, быть готовым к работе в цифровой образовательной среде.

Цифровизация образования как фактор трансформации профессиональной подготовки.

Проблема цифровизации образования становится одним из ключевых направлений реформирования современной образовательной системы. Под цифровизацией понимается процесс внедрения, интеграции и педагогически обоснованного использования информационно-коммуникационных технологий (ИКТ) в образовательную практику с целью повышения качества обучения, расширения доступа к образовательным ресурсам и обеспечения индивидуализации образовательных траекторий [2; 3].

Цифровая образовательная среда - это пространство педагогического взаимодействия, в котором цифровые инструменты становятся не только вспомогательным средством, но и активным компонентом образовательного процесса. Они формируют новые способы организации учебной деятельности, коммуникативного обмена, оценки и рефлексии, а также обеспечивают доступ к мультимедийной информации, виртуальным лабораториям, образовательным платформам и сервисам [4].

Исследователи подчеркивают, что цифровизация требует от будущего учителя не только технической грамотности, но и системы профессиональных компетенций, в которых цифровые и педагогические навыки интегрированы на уровне стратегического мышления и практического применения [5; 6].

Профессиональная компетентность будущего учителя музыки в условиях цифровизации.

Профессиональная компетентность учителя музыки определяется как интегративная характеристика личности, включающая знания, умения, навыки, ценностные ориентации и личностные качества, обеспечивающие успешную педагогическую деятельность [7]. В условиях цифровизации особое внимание уделяется формированию цифровой компетентности как составной части профессиональной культуры педагога [8].

Цифровая компетентность будущего учителя музыки включает способность:

- использовать мультимедийные и интерактивные ресурсы при обучении музыкальным дисциплинам;
- создавать и адаптировать цифровые образовательные материалы;
- организовывать обучение с применением виртуальных инструментов и онлайн-платформ;
- применять цифровые средства диагностики, оценки и мониторинга учебных достижений [9].

Возрастание роли цифровых технологий в профессиональной сфере требует от будущих педагогов развития способности к непрерывному профессиональному саморазвитию, критическому восприятию информации и гибкости в выборе педагогических стратегий [10].

Педагогические условия совершенствования профессиональной подготовки.

Педагогические условия исследования понимаются как системно организованные факторы образовательной среды, создающие предпосылки для целенаправленного формирования профессиональных компетенций. В контексте цифровизации профессиональной подготовки будущего учителя музыки к таким условиям относятся:

1.Организация цифровой образовательной среды. Цифровая образовательная среда должна быть организована таким образом, чтобы обеспечивать свободный доступ к актуальным образовательным ресурсам, платформам и инструментам, способствующим развитию профессиональных знаний и практических навыков [11].

2.Интеграция цифровых технологий в учебные процессы. Педагогические модели должны включать методы и технологии, которые не только облегчают передачу знаний, но и активизируют деятельность студентов: проектные задачи, виртуальные лаборатории звука, создание мультимедийных музыкальных продуктов, онлайн-оценивание [12].

3.Развитие цифровой компетентности. Одним из условий успешной подготовки является системное развитие цифровой грамотности и компетентности в профессиональной деятельности. Это включает формирование способности к выбору, применению и рефлексивному анализу цифровых инструментов в педагогической практике [13].

4.Профессионально-ориентированная мотивация. Цифровые технологии способны повышать мотивацию через интерактивность, мгновенную обратную связь и возможности личного участия в учебном процессе. Мотивация будущего учителя к внедрению инноваций и технологиям представляет собой условие успешной профессиональной социализации [14].

5.Поддержка творческой и рефлексивной деятельности. Творчество и рефлексия являются важнейшими компонентами музыкального образования. Педагогические условия должны обеспечивать включение студентов в проектную деятельность, исследовательские задания, самоанализ собственной учебной и практической деятельности [15].

6.Взаимосвязь педагогических условий, мотивации и профессионального развития. Согласно теории самоопределения, удовлетворение потребностей в автономии, компетентности и связанности способствует формированию устойчивой внутренней мотивации, что способствует успешному профессиональному становлению [16].

В цифровой образовательной среде эти потребности могут быть удовлетворены через выбор учебных задач, интерактивное взаимодействие и самостоятельность в освоении контента.

Интеграция цифровых образовательных технологий и педагогических условий создаёт пространство, в котором студенты могут активно участвовать в учебном процессе, развивать профессиональные компетенции и формировать мотивацию к постоянному саморазвитию. В результате будущий учитель музыки формирует не только профессиональную готовность, но и способность к инновационной педагогической деятельности, адаптивности и метапредметному мышлению.

Методология и инструментарий исследования

Методологическая основа исследования сочетает теоретические и эмпирические методы, направленные на изучение педагогических условий, влияния цифровизации на музыкальное образование и формирование профессиональной идентичности будущих учителей музыки. В рамках исследования применялись: анализ и обобщение современной литературы (2020–2026 гг.), посвящённой цифровизации музыкального образования, развитию цифровых компетенций и формированию профессиональной идентичности преподавателей музыки [17]. Систематизация подходов к интеграции цифровых технологий в обучение музыке, включая онлайн-платформы, цифровые инструменты (цифровое пианино, MIDI-клавиатуры), программы записи и анализа исполнения, видеоруководства и мультимедийные ресурсы [18]. Обобщение исследований по развитию педагогической компетентности, творческой индивидуальности и рефлексии студентов музыкальных вузов, с акцентом на влияние цифровых технологий на личностное и профессиональное развитие будущих учителей музыки [19].

Теоретическая база позволила выделить ключевые направления исследования: формирование профессиональной идентичности педагога музыки в цифровую эпоху, влияние цифровизации на художественно-эстетическое восприятие музыки и педагогические условия эффективной подготовки.

Для эмпирического исследования применялись анкетирование и полуструктурированное интервью, что позволило комплексно изучить восприятие цифровизации и педагогических условий студентами и преподавателями музыкальных вузов. Анкетирование включало 10 вопросов, направленных на изучение: профессионального статуса респондента (студент/преподаватель) и стажа работы или обучения, уровня владения цифровыми технологиями, влияния цифровых технологий на обучение игре на фортепиано и художественно-эстетическое восприятие музыки, используемых цифровых ресурсов (онлайн-платформы, цифровое пианино, MIDI-клавиатуры, программы анализа звука, видеоруководства). А так же педагогических условий, способствующих эффективной подготовке будущих учителей музыки: интеграция цифровых технологий, развитие цифровой грамотности, обеспечение технических ресурсов, мотивация студентов и методическая поддержка, факторов, препятствующих эффективной цифровизации музыкального образования, использование цифровых ресурсов для самоанализа и оценки исполнения, эффективность различных цифровых инструментов для обучения игре на фортепиано, предложения по совершенствованию подготовки педагогов музыки в цифровую эпоху.

Анкета проводилась с 12 студентами и 4 преподавателями вуза на кафедре музыкального образования, соблюдались все этические нормы: участники были проинформированы о целях исследования и дали письменное согласие на участие. Обработка данных включала количественный анализ, что позволило выявить уровень цифровой компетентности респондентов и значимость педагогических условий. Интервью включало 18 вопросов, сгруппированных в пять тематических блоков: профессиональная идентичность педагога музыки: миссия современного учителя музыки и сохранение творческой индивидуальности в цифровой среде, цифровизация и художественно-эстетическое воспитание: способность цифровых средств передавать художественно-эмоциональное содержание музыки, сочетание традиционных и цифровых методов обучения, изменения в восприятии музыки студентами, педагогические условия и инновационные подходы: ключевые организационно-педагогические условия, роль цифровых ресурсов в развитии самостоятельности, рефлексии и креативности студентов, продуктивные формы взаимодействия (проектная работа, коллаборативное обучение, смешанные форматы), личностное и профессиональное развитие: влияние цифровых инструментов на

профессиональный рост, изменения в педагогической культуре, риски чрезмерной цифровизации, навыки и компетенции будущих педагогов музыки, перспективное видение: идеальный педагог музыки XXI века, предложения по совершенствованию системы подготовки, роль сотрудничества традиционной школы и цифровых платформ. Интервью проводились индивидуально, средняя длительность составила 20-25 минут, количество вопросов варьировалось от 10 до 18. Для анализа использовался качественный контент-анализ, включая тематическое кодирование и выявление паттернов в ответах участников. Данные анкеты анализировались количественно для выявления уровня цифровой компетентности и значимости педагогических условий. Ответы интервью обрабатывались качественно, что позволило понять личное восприятие цифровизации, изменения в профессиональной идентичности и педагогических подходах. Использование триангуляции методов, которое обеспечило надежность и валидность результатов [20].

Результаты эмпирического исследования

Анализ данных анкетирования показал, что большинство респондентов положительно оценивают интеграцию цифровых технологий в процесс обучения музыке и их влияние на формирование профессиональной компетентности будущих педагогов. Среди 12 студентов и 4 преподавателей, участвовавших в опросе, 58% отметили, что цифровые технологии существенно улучшают процесс обучения игре на фортепиано, 25% - частично, и только 17% не видят значительного влияния.

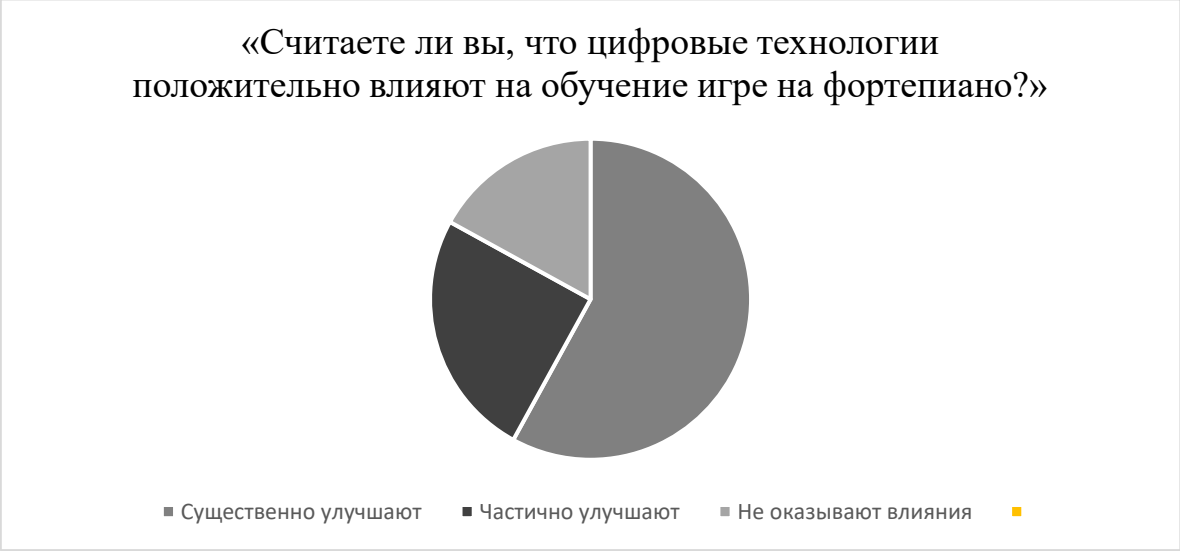
«Считаете ли вы, что цифровые технологии положительно влияют на обучение игре на фортепиано?»
Существенно улучшают
Частично улучшают
Не оказывают влияния

Диаграмма 1. Результаты ответа на вопрос «Считаете ли вы, что цифровые технологии положительно влияют на обучение игре на фортепиано»

Респонденты активно используют цифровые ресурсы: 75% применяют онлайн-платформы (Zoom, Google Classroom), 67% - цифровое пианино и MIDI-клавиатуры, 58% - программы записи и анализа звука (Sibelius, Cubase, Muse Score), а 50% - видеоруководства и YouTube-каналы. Эти данные свидетельствуют о высокой вовлечённости и готовности к интеграции цифровых инструментов в музыкальное обучение. Что касается педагогических условий эффективной подготовки, респонденты выделили следующие ключевые факторы: интеграцию цифровых технологий в учебный процесс (75%), развитие цифровой грамотности преподавателей (67%), обеспечение технических ресурсов (58%), методическую поддержку и повышение квалификации (50%), и мотивацию студентов к использованию технологий (58%). При этом основными препятствиями назывались недостаток оборудования (50%), отсутствие методик преподавания с цифровыми инструментами (42%), низкая цифровая компетентность преподавателей (33%) и ограниченность времени (25%). В области использования цифровых инструментов для анализа и самооценки исполнения 67% участников отметили регулярное применение аудио - и видеозаписи для совершенствования навыков, 25% используют их иногда, а 8% - не используют. На вопрос о наиболее эффективных цифровых ресурсах для обучения игре на фортепиано респонденты указали онлайн-курсы, MIDI-клавиатуры с визуальной обратной связью и программы анализа исполнения.

Анкетирование также выявило потребность в балансировании цифровых и традиционных методов: 58% участников считают, что сочетание живого исполнения с цифровыми средствами повышает качество музыкальной подготовки, тогда как 25% полагают, что цифровые инструменты не всегда передают художественно-эмоциональное содержание музыки.

Качественный анализ интервью с четырьмя респондентами (два студента и два преподавателя) подтвердил данные анкетирования и позволил углубленно изучить восприятие цифровизации музыкального образования. Интервью включало пять тематических блоков: *профессиональная идентичность педагога музыки.* Респонденты отметили, что цифровизация влияет на миссию современного учителя музыки, расширяя возможности для самостоятельного обучения студентов и интеграции новых методов преподавания. В то же время сохраняется важность творческой индивидуальности: «Цифровые инструменты помогают анализировать

исполнение, но не заменяют живое взаимодействие с учеником». *Цифровизация и художественно-эстетическое воспитание:* большинство участников считают, что цифровые ресурсы могут передавать технические аспекты исполнения и визуализировать звук, но художественно-эмоциональное содержание музыки лучше воспринимается при живом исполнении. Респонденты подчеркнули необходимость сочетания традиционных методов обучения с цифровыми платформами: «Онлайн-уроки удобны для анализа, но ансамблевое исполнение невозможно полностью цифровизировать». *Педагогические условия и инновационные подходы:* интервью выявило, что ключевыми условиями успешной подготовки являются доступность цифровых ресурсов, поддержка преподавателей в освоении технологий, проектная и коллаборативная работа, смешанные форматы обучения и развитие навыков рефлексии и самостоятельности. Один из преподавателей отметил: «Цифровая среда помогает студентам видеть свои ошибки и прогресс, но только если есть наставник, который направляет процесс». *Личностное и профессиональное развитие:* респонденты согласились, что использование цифровых инструментов способствует профессиональному росту, повышает самооценку и формирует навыки самообразования. Однако чрезмерная цифровизация может приводить к снижению внимания к художественной составляющей и эмоциональной выразительности музыки: «Слишком много технологий - и теряется живое ощущение музыки». *Перспективное видение*: участники подчеркнули необходимость формирования у студентов цифровой компетентности, креативности и критического мышления. Идеальный педагог музыки XXI века сочетает технологическую грамотность с глубоким пониманием художественного содержания, умеет адаптировать цифровые ресурсы под индивидуальные потребности студентов и поддерживает их творческую самореализацию.

Обсуждение результатов

Анализ данных анкетирования и интервью показывает, что цифровизация музыкального образования оказывает комплексное влияние на формирование профессиональной идентичности будущих педагогов музыки и их творческую активность. Респонденты отмечают, что интеграция цифровых технологий (онлайн-платформы, цифровое пианино, MIDI-клавиатуры, программы записи и анализа исполнения, видеоруководства) существенно расширяет возможности для обучения и саморазвития, позволяя одновременно сочетать традиционные методы музыкального образования с современными цифровыми инструментами. 58% респондентов считают, что цифровые технологии существенно улучшают процесс обучения игре на фортепиано и анализу музыкального исполнения. Это подтверждает, что цифровые ресурсы способствуют развитию навыков анализа, самоконтроля и методической гибкости будущих педагогов. В ходе интервью большинство преподавателей отметили, что использование цифровых инструментов позволяет интегрировать новые формы работы, не теряя художественно-эстетического содержания музыкального произведения. Это согласуется с положениями исследований В. Каримовой и А. Сулейменовой (2022), которые подчеркивают роль цифровых технологий как поддержки, а не замены традиционного музыкального обучения [21]. Использование цифровых инструментов способствует развитию самостоятельной работы, самопроверки и критического анализа собственного исполнения. Это особенно важно для формирования педагогической компетентности и лидерских навыков будущих учителей музыки, подтверждая теоретические положения Л. Выготского о значении инструментальной среды для обучения и саморегуляции [22]. Однако выявлены и проблемные зоны, требующие внимания: некоторые респонденты отмечают недостаточную техническую оснащенность или низкий уровень цифровой грамотности преподавателей, что снижает эффективность использования технологий в обучении. Снижение внутренней мотивации и концентрации на художественной стороне музыки: Хотя цифровые инструменты расширяют возможности для практики и анализа, у ряда студентов наблюдается ориентация на технический результат в ущерб художественно-эстетическому восприятию музыки. Это согласуется с данными исследований Б. Назаровой (2021), показывающими, что чрезмерная цифровизация без методической поддержки может привести к механистическому освоению навыков [23]. Преподаватели подчеркивают, что важно сохранять живое исполнение и ансамблевую работу, интегрируя цифровые средства как вспомогательный инструмент. Отсутствие такого баланса может снизить эмоциональную вовлеченность студентов и ограничить развитие творческой идентичности. В целом, данные подтверждают, что цифровизация музыкального образования способна повысить качество подготовки будущих учителей музыки, если она сопровождается грамотной организацией педагогического процесса и поддержкой профессионального роста преподавателей. Важнейшей задачей остается создание условий, при которых цифровые технологии будут служить средством развития творческих, аналитических и педагогических компетенций, а не заменой художественно-творческой практики.

Таким образом, результаты исследования согласуются с современными теориями педагогики музыкального образования и цифровизации: цифровые технологии усиливают возможности обучения, но требуют методической интеграции и внимания к формированию профессиональной идентичности будущих педагогов музыки [24].

Заключение

Проведённое эмпирическое исследование подтвердило ключевую роль педагогических условий и цифровой образовательной среды в формировании профессиональной идентичности, творческих компетенций и цифровой грамотности будущих учителей музыки. Полученные результаты показали, что интеграция цифровых технологий способствует развитию самостоятельности, аналитических и рефлексивных навыков, а также поддерживает мотивацию и творческую активность студентов. Вместе

с тем выявлены проблемные зоны, связанные с недостаточной цифровой подготовкой преподавателей, ограниченным техническим оснащением и рисками утраты художественно-эстетического восприятия музыки при чрезмерной цифровизации. Дальнейшее углублённое исследование позволит разработать научно обоснованные рекомендации по оптимизации педагогических условий и внедрению сбалансированных цифровых инструментов в процесс подготовки будущих педагогов музыки, обеспечивая гармоничное сочетание традиционных и инновационных методов обучения.

Список литературы

1. Алексеева, И.В. Профессиональная подготовка учителя музыки в условиях цифровой образовательной среды: монография / И.В. Алексеева. - М.: Изд-во Педагогика, 2021. - С. 45-62.

2. Барабанщиков, П.Н. Цифровизация образования: теория и практика / П.Н. Барабанщиков. - СПб.: Питер, 2020. - С. 13-29.

3. Васильева, Т.А. Информационно-коммуникационные технологии в образовательном процессе / Т.А. Васильева. - Екатеринбург: Уральский ун-т, 2019. - С. 101-118.

4. Галкин, С.В. Цифровая образовательная среда как элемент модернизации педобразования / С.В. Галкин // Педагогика и инновации. - 2019. - №4. - С. 22-37.

5. Дмитриева, О.Ю. Педагогическая компетентность и цифровые технологии / О.Ю. Дмитриева. - Казань: Изд-во «Наука и образование», 2022. - С. 76-90.

6. Ефремова, Л.П. Цифровая компетентность педагогов: теоретические аспекты / Л.П. Ефремова // Вестник образования. - 2018. - №2. - С. 7-23.

7. Жданова, М.Н. Профессиональная компетентность будущего учителя музыки / М.Н. Жданова. - Ростов-на-Дону: Феникс, 2021. - С. 33-50.

8. Зверев, В.И. Теория и методика музыкального образования / В.И. Зверев. - СПб.: КАРО, 2020. - С. 152–168.

9. Иванова, Ю.В. Методика создания цифровых образовательных материалов / Ю.В. Иванова. - М.: Академия, 2021. - С. 88-104.

10. Карпов, А.Д. Виртуальные музыкальные лаборатории в обучении / А.Д. Карпов // Образование и цифровые технологии. - 2023. - Т. 2, №1. - С. 55-71.

11. Лебедев, Д.С. Организация цифровой образовательной среды: практика и опыт / Д.С. Лебедев. - Новосибирск: Сибирское ун-т, 2022. - С. 19-36.

12. Миронова, Е.В. Интеграция ИКТ в процессы обучения музыке / Е.В. Миронова // Музыка и образование. - 2020. - №3. - С. 40-58.

13. Николаев, Г.П. Развитие цифровой грамотности будущих педагогов / Г.П. Николаев. - Казань: Изд-во Казан. ун-та, 2019. - С. 102-120.

14. Орлова, С.С. Мотивация студентов к освоению цифровых технологий / С.С. Орлова // Психология и педагогика. - 2018. - №5. - С. 66-79.

15. Павлова, Л.И. Творческая деятельность в профессиональном образовании / Л.И. Павлова. - СПб.: Изд-во Профессия, 2021. - С. 45-61.

16. Харитонов, Ю.А. Теория самоопределения и профессиональная мотивация студентов / Ю.А. Харитонов // Психолого-педагогический журнал. - 2017. - №12. - С. 15-31.

17. Смирнова, А.В. Методология исследования педагогических условий в музыкальном образовании / А.В. Смирнова // Музыкальное образование и инновации. - 2021. - №3. - С. 12-28.

18. Кузнецова, Л.П. Интеграция цифровых технологий в профессиональную подготовку педагогов музыки / Л.П. Кузнецова. — СПб.: Изд-во Профессия, 2022. - С. 45-63.

19. Громова, Е.С. Профессиональная идентичность будущего учителя музыки: теория и практика / Е.С. Громова. - М.: Педагогика, 2020. - С. 77-94.

20. Иванов, Д.В. Треангуляция методов в педагогических исследованиях / Д.В. Иванов // Вестник образовательной науки. - 2019. - №4. - С. 33-49.

21. Каримова, В., Сулейменова, А. Цифровые технологии в музыкальном образовании: поддержка традиционных методов / В. Каримова, А. Сулейменова // Музыка и цифровизация. - 2022. - №2. - С. 14-29.

22. Выготский, Л.С. Психология развития и инструментальная среда обучения / Л.С. Выготский. - М.: Педагогика, 2019. - С. 101-118.

23. Назарова, Б. Чрезмерная цифровизация и влияние на художественно-эстетическое восприятие музыки / Б. Назарова // Образование и инновации. - 2021. - №3. - С. 33-47.

24. Петрова, Е.В. Интеграция цифровых технологий и формирование профессиональной идентичности педагога музыки / Е.В. Петрова. - СПб.: Изд-во Профессия, 2022. - С. 55-72.

ОБРАЗОВАТЕЛЬНАЯ СРЕДА КАК ФАКТОР ПОВЫШЕНИЯ МОТИВАЦИИ И РАЗВИТИЯ ЛИДЕРСКОГО ПОТЕНЦИАЛА УЧАЩИХСЯ

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THE EDUCATIONAL ENVIRONMENT AS A FACTOR IN INCREASING MOTIVATION AND DEVELOPING LEADERSHIP POTENTIAL IN STUDENTS

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Аннотация

Статья посвящена исследованию взаимосвязи компонентов образовательной среды общеобразовательной школы с мотивацией и лидерским потенциалом учащихся старших классов в условиях модернизации системы образования Республики Казахстан. Актуальность работы обусловлена необходимостью формирования у обучающихся инициативности, социальной активности и готовности к самоуправлению как ключевых характеристик современной личности. В исследовании образовательная среда рассматривается как системный фактор, включающий организационные, социально-психологические и содержательные компоненты, способные оказывать влияние на личностное развитие школьников. Цель работы заключается в выявлении взаимосвязи характеристик образовательной среды старших классов с уровнем мотивации и лидерского потенциала учащихся. В рамках исследования проанализированы теоретические подходы к пониманию понятий «образовательная среда», «мотивация» и «лидерский потенциал», определены значимые параметры среды, способствующие их развитию, а также проведено эмпирическое исследование. Результаты показывают, что благоприятный психологический климат, поддержка инициативы, возможности для участия в ученическом самоуправлении и вариативность образовательных практик положительно коррелируют с внутренней учебной мотивацией и выраженностью лидерских качеств старшеклассников.

Abstract

The article is devoted to studying the relationship between the components of the educational environment of a general education school and the motivation and leadership potential of senior school students in the context of the modernisation of the education system in the Republic of Kazakhstan. The relevance of the work is determined by the need to develop initiative, social activity and readiness for self-government in students as key characteristics of a modern personality. In the study, the educational environment is considered as a systemic factor that includes organisational, socio-psychological and content-related components that can influence the personal development of schoolchildren. The aim of the work is to identify the relationship between the characteristics of the educational environment of senior classes and the level of motivation and leadership potential of students. The study analyses theoretical approaches to understanding the concepts of 'educational environment', 'motivation' and 'leadership potential', identifies significant parameters of the environment that contribute to their development, and conducts empirical research. The results show that a favourable psychological climate, support for initiative, opportunities for participation in student self-government, and variability in educational practices correlate positively with internal academic motivation and the expression of leadership qualities in senior high school students.

Ключевые слова: Образовательная среда, Мотивация, Лидерский потенциал, активность обучающихся, школьная атмосфера.

Keywords: Educational environment, Motivation, Leadership potential, Student activity, School atmosphere.

Введение

Современная система образования Казахстана переживает период значительных трансформаций, направленных на формирование у учащихся инициативности, социальной активности и способности к самоуправлению. В этом контексте особую актуальность приобретает изучение образовательной среды как системного фактора, влияющего на развитие личностных качеств обучающихся. Настоящее исследование посвящено анализу взаимосвязи компонентов образовательной среды с мотивацией и лидерским потенциалом учащихся старших классов.

Несмотря на растущий интерес к вопросам школьного климата и личностного развития учащихся в казахстанском контексте, большинство существующих исследований фокусируются на отдельных аспектах проблемы: учебной мотивации, психологическом комфорте, ученическом самоуправлении. Комплексных работ, рассматривающих образовательную среду как системный фактор развития лидерского потенциала во взаимосвязи с мотивацией, пока недостаточно.

Цель данной статьи заключается в выявлении взаимосвязи компонентов образовательной среды

старших классов с мотивацией и лидерским потенциалом учащихся через анализ теории, определение значимых характеристик среды и разработку рекомендаций по её оптимизации на основе эмпирических данных. Задачами исследования являются определение сущностей понятий образовательная среда, лидерский потенциал и мотивация, проанализировать теоретические подходы к взаимосвязи образовательной среды, мотивации и лидерского потенциала учащихся, а также провести эмпирическое исследование и разработать практические рекомендации по оптимизации образовательной среды для развития мотивации и лидерства.

Теоретические основания исследования образовательной среды, лидерского потенциала и мотивации

Понятие образовательной среды в психолого-педагогических исследованиях рассматривается как совокупность условий, факторов и взаимодействий, опосредующих развитие личности обучающегося. Теоретическую основу ее анализа составляют несколько фундаментальных подходов.

В рамках культурно-исторической теории Л.С. Выготского образовательная среда понимается как пространство социального взаимодействия, в котором психическое развитие личности осуществляется через интериоризацию культурных знаков и средств. Ключевым понятием выступает зона ближайшего развития, определяющая потенциал развития обучающегося при поддержке более компетентных субъектов образовательного процесса [1]. По мнению автора, образовательная среда рассматривается не как пассивный фон, а как активный фактор формирования высших психических функций, мотивации и субъектной позиции учащегося.

Экологическая теория развития У. Бронфенбреннера дополняет данное понимание, представляя среду как систему вложенных уровней — от микросистемы (непосредственное взаимодействие учащегося с учителем и сверстниками) до макросистемы (культурные и социокультурные ценности общества) [2]. В контексте образования эта модель позволяет анализировать влияние как внутриклассных процессов, так и институциональных, нормативных и культурных факторов на мотивацию и развитие лидерского потенциала обучающихся.

Существенный вклад в понимание механизмов влияния среды на личность вносит социально-когнитивная теория А. Бандуры, основанная на принципе реципрокного детерминизма, предполагающего взаимное влияние личностных характеристик, поведения и среды. Центральное место в данной теории занимает понятие самоэффективности, отражающее субъективную уверенность человека в собственной способности успешно действовать [3]. Образовательная среда, предоставляющая опыт успеха, возможности наблюдения за моделями поведения и поддерживающую обратную связь, способствует формированию высокой самоэффективности, что, в свою очередь, усиливает учебную мотивацию и готовность к принятию лидерских ролей.

Теоретическое осмысление лидерства прошло значительную эволюцию — от трактовки лидерства как врожденного качества к пониманию его как развивающегося социального и психологического феномена.

В классической социологической концепции М. Вебера лидерство рассматривалось через призму легитимного господства, включая харизматический тип, основанный на исключительных личностных качествах лидера [4]. Данный подход заложил основу для дальнейших исследований, однако ограничивал понимание лидерства рамками индивидуальных характеристик.

Теория черт Р. Стогдилла развила идею личностной обусловленности лидерства, однако последующие эмпирические исследования показали отсутствие универсального набора лидерских качеств, что привело к смещению акцента в сторону ситуационных и контекстуальных факторов [5].

В рамках ситуационной теории Ф. Фидлера эффективность лидерства определяется соответствием стиля лидера характеристикам ситуации [6]. В образовательном контексте это означает необходимость создания разнообразных образовательных ситуаций, позволяющих обучающимся проявлять различные формы лидерского поведения.

Особое значение для педагогической науки имеет теория трансформационного лидерства Дж. Бернса и Б. Басса, в которой лидерство рассматривается как процесс вдохновения и развития последователей [7]. Трансформационное лидерство связано с формированием внутренней мотивации, ценностной ориентации и личностного роста, что делает данный подход особенно релевантным для анализа лидерского потенциала учащихся.

Мотивация как психическое образование является ключевым фактором учебной деятельности и личностного развития.

В теории деятельности А.Н. Леонтьева мотивация рассматривается как опредмеченная потребность, придающая деятельности личностный смысл. Учебная деятельность становится мотивированной лишь в том случае, если ее цели соотносятся с внутренними потребностями обучающегося [8].

Существенное значение имеет теория самоопределения Э. Деси и Р. Райана, в которой подчеркивается роль удовлетворения базовых психологических потребностей – автономии, компетентности и связанности [9]. Образовательная среда, поддерживающая данные потребности, способствует формированию устойчивой внутренней мотивации и психологического благополучия учащихся.

Дополняют данное понимание иерархия потребностей А. Маслоу, теория достижений Д. Макклелланда, атрибутивная теория Б. Вайнера, а также теория ожиданий В. Врума и теория справедливости Дж. Адамса, подчеркивающие значение субъективного восприятия усилий, результатов и справедливости образовательных практик [10; 11; 12; 13; 14].

На основе рассмотренных теорий образовательная среда концептуализируется как многоуровневая экосистема, в которой через социальное вза-

имодействие и активную деятельность формируются мотивационные и лидерские характеристики личности.

Интеграция культурно-исторического, экологического и социально-когнитивного подходов позволяет рассматривать образовательную среду как пространство развития, где удовлетворение базовых психологических потребностей ведет к формированию самоэффективности, внутренней мотивации и готовности к лидерскому поведению. Лидерский потенциал в данной модели выступает не врожденной характеристикой, а результатом системного взаимодействия личности и среды.

Концептуальная модель исследования исходит из предположения, что образовательная среда, поддерживающая автономию, компетентность, связанность, справедливость и психологическую безопасность, создает условия для проявления трансформационного лидерства и устойчивой учебной мотивации.

Методология и инструментарий исследования

Методологическая основа исследования включает как теоретические, так и эмпирические методы. К теоретическим методам относятся: анализ и обобщение литературы. Эмпирические методы включают анкетирование учащихся для выявления уровня мотивации и восприятия образовательной среды, а также полуструктурированное интервью для изучения проявлений лидерства, группового взаимодействия и атмосферы доверия.

Для эмпирического исследования была разработана анкета, состоящая из 60 вопросов с использованием шкалы Лайкерта. Анкета создана на основе методических положений и структуры авторской анкеты Н. Г. Лускановой, представленной в работе *«Методы исследования детей с трудностями обучения»*, с адаптацией к современному контексту казахстанской школы [15] и теорий Л.Выготского, У.Бронфенбреннера, А.Бандура, Э.Деси и Р.Райна, Дж.Бернса и Б.Басса, и других. Теоретическая основа позволяет выделить шесть основных категорий вопросов в анкете: атмосфера и климат (эмоциональный комфорт, безопасность, отношения); поддержка со стороны учителей и сверстников; возможности самореализации и лидерства; учебная мотивация и интерес к обучению; справедливость, сотрудничество и участие; активность, инициатива и вовлечённость в школьную жизнь.

Каждая категория показывает структурные особенности образовательной среды и их влияния на образовательный процесс и вовлеченность учащихся. В первой апробации анкеты приняли участие 11 учащихся 10-11 классов в возрасте 16-17 лет. Перед анкетированием были соблюдены все этические нормы: получены разрешения о проведении анкетирования от места, где проводилось исследование, а также от официальных представителей учащихся. Учащиеся были ознакомлены с темой и целями исследования. Анализ полученных данных позволил выявить как сильные стороны образовательной среды, так и проблемные зоны, требующие внимания. Пробное анкетирования проводилось в течении двух недель.

Для сбора дополнительной качественной информации, которое дополнит понимание основных объектов исследования со стороны участников, что повлияет на снижения субъективности данных во стороны исследователей. Интервью основывалось на шести ключевых категориях, использованные в анкете. Структура интервью строилась следующим образом: первая часть, включающая знакомство респондента с интервьюером, описание темы и целей исследования, сбор биометрической информации респондента (пол, возраст, класс обучения); вторая часть, содержащая основные вопросы (описание атмосферы в классе и школе; ситуации, в которых ощущается поддержка со стороны преподавателей и одноклассников; возможности проявления инициативы и лидерских качеств в школе; факторы, способствующие сохранению интереса к учебе и мотивации; оценка справедливости школьной жизни и проявление активности в общешкольных делах), а также дополнительные вопросы, появлявшиеся во время интервью. В интервью приняли участие четыре учащихся 10-11 классов (два мальчика и две девочки). Общее количество вопросов в каждом интервью варьируется от 10 до 18. Средняя длительность интервью составило 18 минут.

Результаты эмпирического исследования

Результаты анкетирования демонстрируют, что большинство учащихся воспринимают образовательную среду как комфортную и безопасную. Значительная часть респондентов полностью согласны с утверждением о том, что они чувствуют себя комфортно в классе (55%), ощущают безопасность (55%) и поддержку со стороны одноклассников (46%). Эти данные свидетельствуют о позитивном эмоциональном климате, что является важным фундаментом для развития мотивации и лидерских качеств.

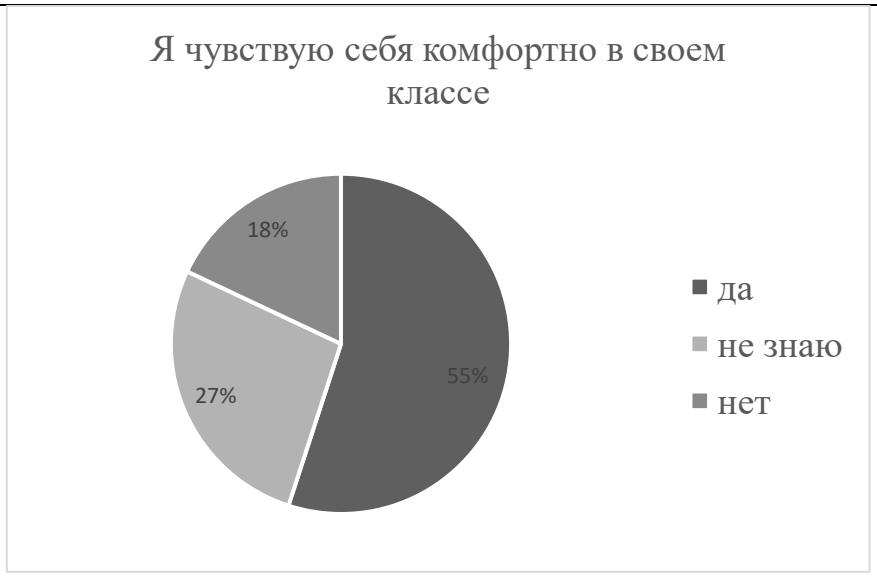

Диаграмма 1. Результаты ответов на утверждение «Я чувствую себя комфортно в своем классе»

Высокая мотивация и вовлеченность также характеризуют данные анкетирования. Значительная часть опрошенных мотивирована к учебе (46%), уверена в своих лидерских качествах (55%) и чувствует, что их мнение влияет на изменения в школе (46%). Особенно показательным является высокий уровень готовности участвовать в школьных проектах (57%) и проявления инициативности (46%). Эти результаты указывают на наличие возможностей для самореализации и развития лидерского потенциала в рамках школьной среды.

Позитивное отношение к учителям является еще одной важной характеристикой образовательной среды. Учителя воспринимаются учащимися как те, кто относится с уважением и пониманием (46%), помогает анализировать успехи (55%), делает обучение увлекательным (46%) и поощряет инициативность (46%). Эти данные подтверждают значимость педагогической поддержки в формировании мотивации и лидерских качеств учащихся.

Несмотря на общие позитивные тенденции, анкетирование выявило ряд проблемных областей, требующих внимания. Академическое давление проявляется в том, что существенная часть учащихся испытывает трудности с заданиями, требующими творчества (46% не согласны), и чувствует давление со стороны сверстников при соревнованиях (56% не согласны). Эти данные указывают на возможную несбалансированность образовательной среды в сторону стандартизированных форм обучения в ущерб творческому развитию.

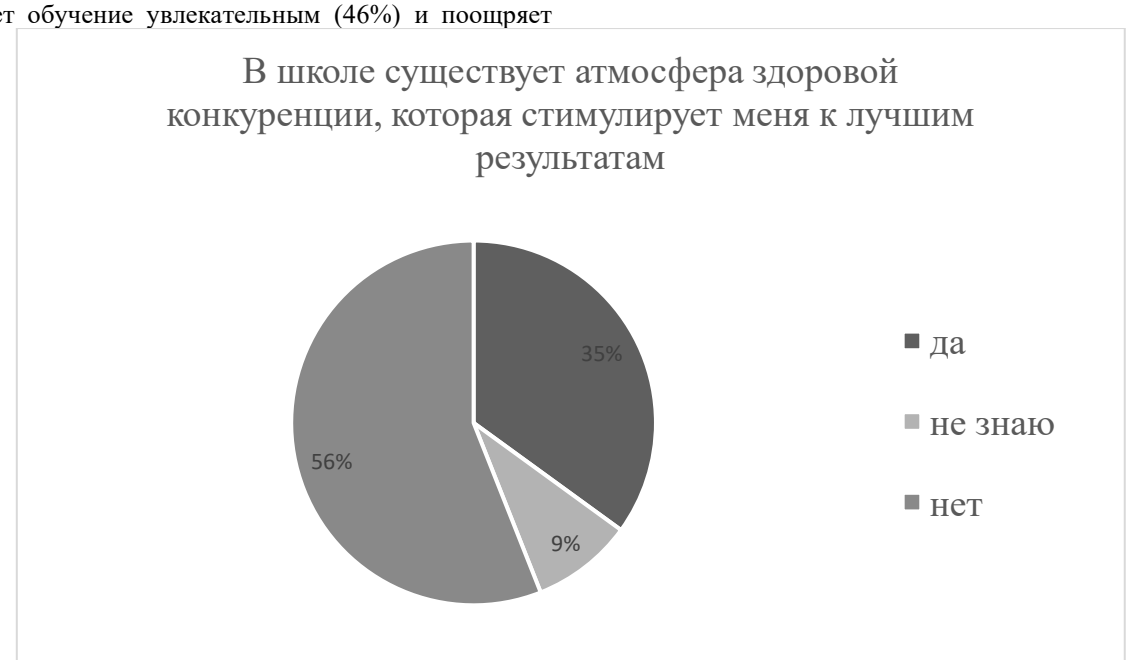

Диаграмма 2. Результаты ответов на утверждение «В школе существует атмосфера здоровой конкуренции, которая стимулирует меня к лучшим результатам»

Коммуникация и обратная связь представляют собой еще одну проблемную область. Около трети

учащихся (36%) не получают достаточной конструктивной обратной связи от учителей по учебной деятельности. Также заметна проблема с получением поддержки при обсуждении своих ошибок (36%). Недостаток качественной обратной связи может негативно влиять как на учебную мотивацию, так и на развитие рефлексивных навыков, необходимых для лидерства.

Недостаточная персонализация образовательного процесса проявляется в том, что значительная часть учеников не получает удовлетворения от участия в школьных мероприятиях (36%). Это может свидетельствовать о недостаточном учете индивидуальных интересов и потребностей учащихся при организации школьной жизни, что снижает возможности для развития внутренней мотивации и самореализации.

Качественный анализ интервью позволил получить более глубокое понимание факторов, влияющих на мотивацию и развитие лидерского потенциала. Позитивные аспекты образовательной среды, выявленные в ходе интервью, подтверждают результаты анкетирования. Эмоциональный климат в целом оценивается положительно: большинство учащихся чувствуют себя комфортно и безопасно, отмечают дружелюбие и поддержку одноклассников. Дружеские связи характеризуются наличием друзей, взаимопомощи и нормальных конкурентных отношений. Один из респондентов рассказывает: «У меня есть очень хороший преподаватель по математике. И вот недавно я писал экзамен для поступления в Турцию. Я подхожу к ней, говорю, что вот, я не уверен в том, что я хорошо набрал. Я показал ней эти задания, она говорит, ничего страшного, у тебя еще одна попытка. И мы потом сели после урока, около полутора часа, может, два, разбирали задание. Самая важная поддержка со стороны преподавателя была. Да и в целом учительница математики всегда вот такой…». Это показывает важность поддержки со стороны не только учеников, но и учителей.

Однако интервью выявило и серьезные проблемные зоны. Неработающая атмосфера в некоторых случаях характеризуется тем, что значительная часть учащихся (около 70%) не заинтересованы в учебном процессе, встречаются случаи конфликтов и напряженности. 3 из 4 респондентов сошлись во мнении что здоровой конкуренции и слаженности в их классах не хватает, из-за чего у респондентов снижается мотивация и желание к обучению. Избирательная поддержка со стороны учителей также вызывает озабоченность: наблюдается, что поддержка может быть избирательной, при этом учащиеся отмечают, что «лучших больше любят». Это создает неравные условия для развития лидерского потенциала и может негативно влиять на мотивацию некоторых учащихся.

Анализ мотивационных факторов выявил значительную дифференциацию среди учащихся. Сильные стороны мотивационной сферы проявляются у тех учащихся, которые демонстрируют высокую внутреннюю мотивацию, интерес к учебе, стремятся получать хорошие аттестаты и развивать навыки. У этих учащихся присутствует понимание важности образования для будущего, что формирует устойчивую основу для развития как учебных достижений, так и лидерских качеств.

Однако критические проблемы в области мотивации вызывают серьезную озабоченность. Низкая внутренняя мотивация характерна для значительной части учащихся, которые учатся только ради оценок, под давлением родителей или «потому что нужно». Отсутствие интереса проявляется в том, что многие считают учебу неинтересной, а профиль класса не соответствует их интересам. Внешняя зависимость мотивации строится на страхе наказания и желании получить аттестат, но не на внутреннем интересе к знаниям. Эти факторы создают неблагоприятные условия для развития лидерского потенциала, поскольку истинное лидерство требует внутренней мотивации и увлеченности деятельностью.

Обсуждение результатов

Результаты апробации анкеты и интервью в целом подтверждают теоретические положения о значимости образовательной среды для развития мотивации и лидерского потенциала учащихся. Данные показывают, что образовательная среда представляет собой сложную многокомпонентную систему, в которой различные элементы оказывают как положительное, так и отрицательное влияние на развитие личностных качеств учащихся.

Позитивные аспекты образовательной среды, выявленные в исследовании, создают благоприятную основу для развития мотивации и лидерства. Комфортная атмосфера, поддержка со стороны одноклассников и учителей, возможности для проявления инициативы согласуются с теорией самоопределения Э. Деси и Р. Райана, подчеркивающей важность удовлетворения базовых психологических потребностей в автономии, компетентности и связанности с другими для развития внутренней мотивации [9].

Однако проблемные зоны, выявленные в исследовании, указывают на существенные барьеры в развитии лидерского потенциала и мотивации. Недостаток качественной обратной связи, академическое давление, ориентация на внешнюю мотивацию и избирательная поддержка создают условия, при которых развитие лидерских качеств и внутренней мотивации затруднено.

Особого внимания заслуживает выявленная проблема низкой внутренней мотивации у значительной части учащихся. Преобладание внешней мотивации, основанной на оценках и давлении родителей, свидетельствует о недостаточной реализации потенциала образовательной среды в формировании устойчивого интереса к обучению. Согласно теории самоопределения, такая ситуация препятствует развитию автономной мотивации, необходимой для проявления лидерских качеств.

Заключение

Проведенная первичная апробация подтверждает значимость образовательной среды как системного фактора развития мотивации и лидерского потенциала учащихся старших классов. Полученные результаты свидетельствуют о наличии как благоприятных условий, так и существенных

проблемных зон в современной образовательной среде казахстанских школ. Дальнейшее исследование позволит углубить понимание механизмов влияния образовательной среды на личностное развитие учащихся и разработать научно обоснованные программы её оптимизации.

Список литературы

1. Выготский Л.С. Мышление и речь. М.: Педагогика, 1982. – 504 с.
2. Бронфенбреннер У. Экология развития человечества: рассуждает и ставит эксперимент. М.: РОССПЭН, 2019. – 512 с.
3. Бандура А. Теория научных исследований. СПб.: Евразия, 2000. – 320 с.
4. Вебер М. Харизматическое господство // Социологические исследования. 1988. № 5. – С. 139-147.
5. Стогдилл Р. Личностные факторы, связанные с лидерством: обзор литературы // Психология лидерства. М.: Прогресс, 1975. – С. 45-71.
6. Фидлер Ф. Теория эффективности лидерства. М.: Экономика, 1995. – 256 с.
7. Басс Б.М. Трансформационное лидерство: промышленное, военное и образовательное влияние. М.: Смысл, 2015. – 528 с.
8. Леонтьев А.Н. Деятельность. Сознание. Личность. М.: Политиздат, 1975. – 304 с.
9. Деси Э., Райан Р. Самодетерминация и внутренняя мотивация в поведении человека // Психология мотивации. М.: Смысл, 2012. – С. 224-295.
10. Маслоу А. Мотивация и личность. СПб.: Евразия, 1999. – 478 с.
11. Макклелланд Д. Мотивация человека. СПб.: Питер, 2007. – 672 с.
12. Вайнер Б. Атрибутивная теория мотивации достижений // Психологический журнал. 1986. Т. 7. № 6. – С. 134-147.
13. Врум В. Теория ожиданий: работа и мотивация. М.: Вильямс, 2008. – 384 с.
14. Адамс Дж. Теория справедливости в социальном обмене // Современная зарубежная социальная психология. Тексты. М.: Издательство МГУ, 1984. – С. 120-138.
15. Лусканова Н.Г. Методы исследования трудностей обучения детей. М.: Фолиум, 1993. – 32 с

PHILOLOGICAL SCIENCES

THE EPIC TREASURE OF THE TURKIC PEOPLES: THE KOROGLU EPIC

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Abstract

This article explores the emergence of the epic 'Koroglu' among the Turkic peoples, its regional variations, and its cultural and historical significance. It aims to examine the epic's connection to historical events of the 16th–17th centuries and ancient mythological layers, as well as showing the differences in plot, hero and motifs between the various versions in a comparative manner. Methods used in the study include the analysis of literary works and the research of scholars such as I. Abbasli, B. Karriyev, Elza Ismayilova, Banarly and J. Dumzeil, as well as plot-motif comparison and geographical-mythical spatial studies. The study reveals that the Azerbaijani version is the primary source of all others, with the Caucasus-Anatolian variants favouring historical, realistic and heroic motifs and the Central Asian-Turkestan variants favouring mythological and romantic elements. The 'Chenlibel' motif combines the real, intermediate, and ideal spatial layers of the epic, symbolising freedom, courage, and unity. Additionally, the motif of Koroglu's heroism and struggle for social justice has been preserved in all versions. This comparative analysis highlights the epic's scientific importance not only in literary studies but also in folklore, historiography and cultural studies. It also sheds light on the formation of a shared cultural and historical memory among Turkic peoples.

Keywords: Koroglu Epic, Turkic Peoples, Epic Heritage, Comparative Analysis, Chanlibel Motif, Azerbaijani Epic, Historical and Mythological Layers.

Introduction

The epic Koroglu is one of the most important examples of the Turkic peoples' epic heritage, and is of great importance from literary, historical, and ethnographic points of view. The epic is widespread among various Turkic peoples, each of which has its own version reflecting its national characteristics. Studying these versions and variants is therefore of great scientific importance when it comes to exploring the common cultural roots and different development paths of the Turkic peoples.

Studying the different versions of the Koroglu epic enables us to gain insight into the intercultural relations, shared history, and folkloric traditions of the Turkic peoples. Such studies also demonstrate how the epic has evolved over time, which motifs have been preserved and how new elements have been introduced. Therefore, comparative analysis of the Koroglu epic's versions and variants is important not only in literary studies, but also in cultural, historical and social sciences.

The epic “Koroglu” has undergone a process of cultural transformation among the Turkic peoples, taking on the characteristics of their worldview, historical experience and socio-cultural environment. Consequently, different features are evident in various versions and variants of the epic. In the folklore of some Turkic peoples, for example, Koroglu is presented in connection with historical events and real heroic traditions. In the folklore of other Turkic peoples, however, the epic attracts attention due to its mythological layers, miraculous elements and unusual plot line. This diversity is primarily due to the richness of the thinking, lifestyles, and worldviews of the people who created and perpetuated the epic.

The fact that 'Koroglu' has existed in such a wide geographical area and been expressed in various folkloric traditions shows that it is not only a heroic epic, but also a pan-Turkic epic monument that preserves the shared memory, moral values and national-cultural identity of Turkic peoples. Each people has made “Koroglu” their own by incorporating their cultural codes, social ideals and heroic ideas into the epic, thus creating an epic heritage of both national and pan-Turkic significance.

The genesis of the 'Koroglu' epic, with its historical foundations, mythological layers, wide distribution area and rich variants, is of special scientific importance in the context of folklore studies.

Main part

1. The Genesis of the Epic "Koroglu": Historical Foundations and Mythological Layers.

There are various scientific theories about the origins of the epic. Some researchers emphasise its connection with the 16(th) century and explain it as an artistic reflection of the Jalali rebellions. Others emphasise that the plot of the epic has roots that go back to ancient times. These approaches are based on various facts, including plot motifs that resonate with 16(th)-century events, parallels in historical documents from that period, and the testimony of certain sources.

Researchers have various views on the origins and reasons for the creation of the epic "Koroglu". Some scientists evaluate the epic as resulting from historical events and real personalities, examining its hero images and storylines within a specific historical context. Other researchers emphasise the dominance of mythological elements in the epic's main motifs and symbols, considering it a product of the collective imagination and mythological worldview of the people.

According to I. Abbasli, the Koroglu epic originated in the 16th–17th centuries, a period characterised

by peasant movements and socio-political dynamism. B. Karriyev (based on the A. Khodzko version) notes that 'the South Azerbaijani version collected by A. Khodzko in the first half of the 19th century was older, fuller and more reliable than the others. It speaks of events that took place in South Azerbaijan and neighbouring countries in the 16(th)-17(th) centuries, about which A. Tabrizli and M. Elyas also provided information". [2,9]

J. Dumezil confirms the existence of the Koroglu motif among the Turks in the 6th century BC based on Herodotus's information about children born from the union of blinded slaves with Scythian women who opposed the Scythians returning from war.

N. S. Banarlı attributes the creation of the epic to the Turkish–Iranian wars of the Göktürk period.

B. Haggi not only dates the creation of the epic 'Koroglu' to a specific historical period, but also inextricably links its origins to the mythological era. He views Koroglu as an ancient ritual performed by our ancestors to welcome the new year and usher in spring.

Elza Ismayilova argues against those who attribute the Koroglu epic solely to myth, noting that the dominance of mythological ideas in Turkish thought during the 16th and 17th centuries is not compatible with scientific principles. Like other epics, the Koroglu epic has an unusual character, but it is far from myth. [12, 123

Various positions have been put forward by researchers regarding the history and source of the epic. These can generally be grouped according to historical justifications and mythological explanations.

I. Abbasli, A. Khodzko, B. Karriyev and E. Ismayilova take a more historical approach to the epic. In contrast, J. Düzgün, Banarlı and B. Hacı associate the origins of Koroglu with mythological elements and attribute its history to ancient times.

Both approaches accept 'Koroglu' as a product of the collective memory of the people, confirming that the idea of heroism, freedom and rebellion against oppression occupies a central place in the epic. The difference between the two approaches is that the historical approach connects the source of the plot with socio-political events of a specific period, while the mythological approach seeks the roots of the plot in ancient rituals and myths. In contrast, the mythological explanation seeks the roots of the plot in ancient rituals and myths, viewing the epic as a continuation of these mythological layers.

A comparison of the facts reveals traces of historical events and mythological ideas in the epic. However, the epic's main artistic power stems from the ideological and political environment of the peasant movements of the 16th–17th centuries. Mythological motifs serve to reinforce this historical foundation. Therefore, it would be incorrect to evaluate the epic as either purely mythological or purely historical; it is a national epic born from the synthesis of both. This synthesis shows that the epic is not just a product of a single era, but a monument of collective memory, refined over many centuries.

2. The Koroglu settlement area and the Chanlibel motif.

The epic poem Koroglu, which is culturally and historically significant as a heroic epic of the Turkic peoples, is widespread in Azerbaijan, Turkey, Iran, Turkmenistan, Uzbekistan and Tajikistan, among other regions, and has evolved in accordance with the cultural characteristics of each nation. One issue related to the geography of its spread concerns the motif of Koroglu's settlement, Chanlibel. The exact location of Chanlibel is a key topic of debate in epic studies.

In his research, A. Khodzko associates the creation and spread of the epic poem Koroglu mainly with northern Iran and the Caspian littoral lands. He also suggests that this epic belongs to the inhabitants of that region. [2, 4].

Sadig states that Chanlibel is located in the Ganjabasar region of Azerbaijan, between the Shamkir and Gadabay regions. Other sources state that Chanlibel is located either near Salmast in the Iranian province of Azerbaijan or near Sebastia in Turkey. According to E. Muşeg's notes, the place where Koroghlu lived was a forest called Soğanlı, located between Gerni and Kars.I. Abbasli (referring to V. M. Zhirmuniski and X. T. Zarifov) notes that all considerations on this matter converge around the idea that researchers searching for Chanlibel in various parts of Transcaucasia (mainly Azerbaijan, but also Armenia, Georgia, Anatolia, and Central Asia) based their searches on different versions of the epic. They connected this diversification with the epic's widespread distribution in these areas and interpreted the nuances of the name as 'pine forest' or 'pine waist'. [3,23].

From what has been said, we can conclude the following:

2.1. There is a diversity of geographical considerations and the concept of mythical space.

These differences indicate that the epic's mythical geography manifests itself differently in the collective memory, revealing that its geographical and symbolic layers differ.

2.2. Functional stratification of space: real, intermediate, and ideal space.

The epic's spatial structure is analysed in three layers: real space (e.g. Azerbaijan, Istanbul, Kars and Erzincan); an intermediate space that resolves conflicts; and an ideal space, Çanlibel. This layering strengthens the dramaturgy of the epic, connecting the heroic motifs with the spatial context. In this respect, Çanlibel serves as both an actual living space and a poetic refuge where the heroes gather.

2.3. Symbolic and ideological role.

Çanlibel is not only a geographical concept, but also a poetic symbol representing the ideas of freedom, unity and brotherhood in the epic. The large number of heroes gathered here, and the magnificence of their numbers (for example, 'seven thousand seven hundred seventy-seven'), symbolise the power and greatness of the people. This demonstrates that the space is a product of collective imagination, emphasising its poetic function.

2.4. The synthesis of space with collective consciousness and cultural memory.

The Çanlibel motif is not confined to physical space; it has become a symbol of the people's idealised

freedom and courage. Its association with different geographical locations in various regions indicates the epic's widespread distribution and cross-cultural influence. Thus, as both a real and an ideal place, Chanlibel serves as the epic's spiritual and cultural foundation.

3. Analysis and comparison of different versions of the Koroglu epic.

As a heroic epic of the Turkic peoples, the Koroglu epic has cultural and historical significance. Due to its widespread dissemination among different peoples, various versions and variants of the epic have emerged. Each variant emerged and developed in response to regional, historical and cultural contexts, with plot lines and hero images adapted to suit each region. These variants are distinguished by their unique features, particularly in Azerbaijan, Turkmenistan and Central Asia, and have been comparatively studied by researchers. This diversity ensures that the epic covers both historical events and mythological elements and folklore.

Israfil Abbasli notes that the Koroglu epic is divided into three parts according to differences in content and plot.

1. Turkmen
2. Azerbaijani
3. Asia Minor variants.

Having studied the 'Koroglu' corresponding to that division, P.N. Boratav concluded that the Azerbaijani epic is the basis of all these variants and versions. The idea that the main plot of the epic originated in Azerbaijan is also noteworthy as a continuation of this line of reasoning. The idea that the Caucasian versions of the epic (Georgian, Armenian, Kurdish, Lezgi and Avar) centre around the Azerbaijani variant and that the Turkmen, Tajik and Kazakh variants, as well as the Central Asian Arab variant, centre around the Uzbek 'Koroglu' somewhat coincides with the aforementioned division.

V.M. Zhirmunsky and H.T. Zarifov summarised their views on this problem as follows: 'The Azerbaijani version of Koroglu incorporates all the remaining Middle Eastern and Transcaucasian Turkish, Georgian and Armenian variants.' According to the article 'Koroglu' in the Kazakh Soviet Encyclopaedia, the epic consists of two parts:

1. Western: Azerbaijani, Armenian, Georgian, Kurdish, and Turkish versions.
2. Eastern area: Turkmen, Uzbek, Tajik and Kazakh.

In her research work, 'The Koroglu Dastan', M. Gumarova emphasises that scholars such as A. K. Borovkov, I. S. Braginsky, L. I. Klimovich, V. M. Zhirmunsky, Kh. T. Zarifov, V. I. Chicherov and B. A. Garriev, who worked on the Koroglu Dastan, spoke about two areas of the epic.

1. The Azerbaijani area: Azerbaijani, Armenian, Georgian, Kurdish and Turkish variants.
2. Turkmen Area: Turkmen, Uzbek, Kazakh and Tajik. Variants from Karakalpaks, Siberian Tatars and Bukhara Arabs can also be added to this area. [11]

A. Nabiyev takes a slightly different position to that which has been suggested. He notes that, in terms of scope, it does not make sense to present the 'Transcaucasia', 'Central Asia', 'Western' and 'Eastern' versions under the name 'Transcaucasia'. Therefore, it is more appropriate to organise them as follows:

1. Caucasus-Anatolia
2. Turkestan versions'.[1]

We can therefore conclude that:

3.1 Regional classification: The 'Koroglu' epic is primarily divided into the Caucasus-Anatolian (Azerbaijani, Georgian, Armenian, Kurdish and Turkish) and Central Asian-Turkestan (Turkmen, Uzbek, Kazakh, Tajik, Bashkir and Arab) regions, due to differences in content and plot.

3.2 The central role of the Azerbaijani variant: Studies by P. N. Boratav and other researchers show that all variants are based on the Azerbaijani epic. The Caucasian variants were formed around the Azerbaijani Koroglu, while the Central Asian Turkestan variants initially developed around the Turkmen and Uzbek Koroglu.

3.3 Differences in content between the Western and Eastern variants: The Azerbaijani and Anatolian (western) variants are set against the backdrop of real historical events with mythological elements in the background. In contrast, the Central Asian (eastern) variants feature mythological and fantastic elements more prominently.

4. Comparative analysis of some versions of the Koroglu epic (Azerbaijani, Turkish, Uzbek and Turkmen).

In the Azerbaijani version, Koroglu's struggle against social injustice begins with a personal revenge motive, inspired by his father's gouged-out eye. While largely preserving this plot line, the Turkish version foregrounds the hero's mission of fighting oppression. In the Turkmen version, the motive of Jigaly Bey, Koroglu's grandfather, being blinded activates the hero's sense of revenge and is presented as the reason for beginning the struggle. In the Uzbek version, the legendary struggle for justice of Rovshan's son, Goroglu, who was blinded, forms the centre of the plot.

Let's compare the versions of the epic.

1. In the Caucasus-Anatolian version, historical accuracy is emphasised, whereas the Turkestan version has a legendary character.

2. In the Azerbaijani and Turkish (Caucasus-Anatolian) versions, the hero's name is Koroglu/Köroglu; in the Turkmen and Uzbek (Turkestan) versions, it is Goroglu.

3. In the Caucasian-Anatolian version, Koroglu is the blind son of Man Ali, whose eyes were gouged out. In the Turkestan version, he is called Goroglu Gabir Oglu because he was found in a grave.

4. In the Azerbaijani and Turkmen versions, the main character's real name is Rovshan. In the Turkish version, it is Rushen or Rushen Ali. In the Uzbek version, it is Goroglu.

5. In the Azerbaijani version, his father is called Ali; in the Turkish version, he is called Yusuf; in the Turkmen version, he is called Bey (he dies of his own accord); and in the Uzbek version, he is called Rovshan.

6. There is no information about his mother in the Caucasian-Anatolian version. However, there is information about her in the Turkmen and Uzbek versions.

7. Blinding is a common theme in all versions. In the Azerbaijani and Turkish versions, it is his father Ali (or Yusuf) who is blinded on horseback; in the Turkmen version, it is his grandfather Jigaly Bey; and in the Uzbek version, it is his father Rovshan.

8. The Turkestan version provides information about the childhood of the main character; in the Azerbaijani version, he is already an adult.

9. Although both versions of the epic contain mythological elements, the Central Asian version is more akin to a fairy tale.

10. In the Caucasian-Anatolian version, there is a madman, a magic sword and a legendary horse, as well as the water of Goshabulakh. In the Uzbek Koroglu, there are the Forties, twelve imams, fairies, a giant and a dragon. In the Turkmen version, there are religious, mythical and legendary motifs, such as Imam Reza and Hz. Ali, Khizr and fairies.

11. In the Azerbaijani version, he has one wife, Nigar Khanum. (In some variants, Momina Khatun is also mentioned.)

In the Turkmen version, he has three wives: Yunis Pari, the daughter of Rahmet Pari, the king of the Kufi-Qaf fairies; his friend Misgal Pari; and Gulnar Pari, about whom there is a separate epic.

12. In the Turkish version, the hero is an ashug like the Azerbaijani Koroglu. However, in the Uzbek version, he does not have the skills of an ashug and does not play the saz.

13. In the Caucasian-Anatolian and Turkestan versions, the theme of adoption is explored (in both versions, the issue of childlessness in the maternal line is addressed).

Note: in the Caucasian-Anatolian version, Avaz/Eyvaz has one or two children with Momuna Khanum (Kürdoğlu and Hasan), whereas in the Uzbek version, Avaz and Hasan have their own children. Eyvaz/Avaz is the son of a butcher in both versions.

14. In the Caucasus-Anatolia version, Koroghlu has 7,777 madmen heroes, whereas in the Turkestan version (Turkmen and Uzbek), he has just 40.

15. In the Caucasus-Anatolia version, Koroghlu is the son of ordinary people. In the Uzbek version, however, his father is poor, but his maternal uncle and mother are from the lineage of the bey. In the Turkmen version, he is the son of Jığalı Bey and grandson of Adi Bey; in other words, he is from the Bey's lineage.

16. In both versions, the importance of unity with and reliance on the people is reflected.

17. In both versions, their spouses are their closest confidants and aides.

18. In the Caucasian-Anatolian version, the name is derived from the sea stallion. In the Turkestan version, it is derived from the horse of a particular individual. In the Uzbek version, it is derived from the legendary horse of Arab Reyhan.

19. Although the winged horse motif is present in both versions, the ending is different. In the version where historical accuracy is emphasised, the horse's wings do not appear due to Rovshan's impatience and lack of restraint. In the Uzbek version, however, this motif is preserved (winged horse).

In conclusion, the results of the study show that the epic Koroglu has literary, cultural, historical and social significance in terms of the epic heritage of the Turkic peoples. Its spread among different peoples, and the way it reflects the national-cultural codes of each, reveal both its regional adaptations and common epic roots.

The Azerbaijani version forming the basis of all others and the plot being established here confirms this epic heritage's central role as a source. While the Caucasian-Anatolian versions prioritise historical realism and heroic motifs to bring the socio-political message of the epic to the fore, the Central Asian-Turkestan versions strengthen the legendary character of the epic with their mythological and romantic elements.

The Chanlibel motif is particularly important in this discussion. It enriches the dramaturgy of the epic by combining real, intermediate, and ideal spatial layers, while expressing the ideas of heroism and freedom through poetic symbolism. Despite various geographical classifications, the motif of Chanlibel, representing both an actual place of residence and a product of the cultural collective imagination, ensures the regional and universal appropriation of the epic. A comparative analysis of the epic also reveals that motifs such as heroism, social justice and the struggle for freedom are universal themes. The Azerbaijani and Turkmen versions emphasise the hero's social roots, adoption and connection with the people, while the Uzbek and Turkmen versions feature mythological and legendary motifs such as fairies, giants and winged horses, which enhance the romantic-epic tone. These differences suggest that the epic is significant not only in the artistic analysis of historical events and real heroic motifs, but also in the study of folklore, mythology, and collective cultural memory.

Thus, the epic "Koroglu" is a multilayered cultural heritage that emerged from the synthesis of both historical and mythological layers, preserving the common cultural memory and epic heroic traditions of the Turkic peoples.

Generalization:

1. The epic "Koroglu" is a central example of the common epic heritage of the Turkic peoples, and despite regional differences, the motifs of heroism, freedom and struggle for justice have been preserved in all variants.

2. The Azerbaijani version of the epic is the main source of all others; the Caucasus-Anatolia and Central Asia-Turkestan versions differ in terms of their historical and mythological layers due to regional characteristics.

3. The Chanlibel motif plays an important role in the epic's spatial structure, functioning as real, intermediate and ideal spaces, and symbolising freedom, courage and togetherness.

4. A comparative analysis shows that Caucasian-Anatolian variants favour historical, realistic and heroic motifs, whereas Central Asian-Turkestan variants favour mythological and romantic elements.

5. The epic Koroglu should not be evaluated as purely historical or mythological; it is a multilayered

epic heritage formed from the synthesis of both, reflecting the cultural and historical memory of Turkic peoples.

References

1. Nəbiyev, A. Azərbaycan xalq ədəbiyyatı: [2 cilddə] / A. Nəbiyev. – Bakı: Elm nəşriyyatı, - c. 1. – 2006. – 685 s.
2. Koroğlu: Paris nüsxəsi / tərt. ed İ. Abbaslı – Bakı: Şərq-Qərb, - 2005. – 224 s.
3. Koroğlu: / tərt. ed İ. Abbaslı, B. Abdulla – Bakı: Lider nəşriyyatı, – 2005. – 552 s.
4. A, Goli. Görogly. Türkmen Halk Eposy/ Goli.A. – Aşgabat: Turkmenistan Neşriyaty, -1980. – 563 s.
5. Əfəndiyev, P. Azərbaycan şifahi xalq ədəbiyyatı. Dərslik. / P. Əfəndiyev – Bakı: ADPU, – 2019. – 600 s.
6. Sadıq, İ. Azərbaycan "Koroğlu" eposu: [I kitab] / İ. Sadıq. – Bakı: Elm və Təhsil nəşriyyatı, - 2015. – 248 s.
7. Gorogli: Ozbek xalq dostonlari / Aytuvchi Rahmatulla shoir Yusuf o'g'li; Tahrir hay'ati: O. Yunusov, A. Ahmedov, M. Jo'rayev va boshq./Rassom T. Sa'dulla. -T.: Sharq, 2006. - 448 b.
8. Bayat, F. Koroğlu dastanının mənşəyi. Dərs vəsaiti / F. Bayat, X. Bəşirli – Bakı: Elm və təhsil, – 2012. – 192 s.
9. Həqqi, B. *"Koroğlu" – tarixi-mifoloji gerçəklik* / B. Həqqi. – Bakı: Nurlan, – 2003. – 316 s.
10. Sağdıç, H. Koroğlu Dastanının Qazaxca Cambil Nüsxəsi: / Yüksek Lisans Tezi. /- İstanbul, 1998. – 133 s.
11. https://tdk.gov.tr/wp-content/uploads/2014/09/1997_03_06_Gumarova.pdf
12. http://dspace.khazar.org/bitstream/20.500.12323/1402/1/Koro%C4%9Flu-zakir-jurnalll.pdf

DIGITAL TRANSFORMATION OF CLASSICAL POETIC DISCOURSE: IN THE CONTEXT OF BAKHTIYAR VAHABZADEH'S WORK

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Abstract

Literature is a field that reflects life through images and is directly related to the period in which it was created. Philosophical thoughts and trends are also influential factors in the creation of literary material. Rules polished over time, forms accepted as standards acquire classical value. The work of Bakhtiyar Vahabzadeh, a prominent representative of Azerbaijani literature who lived and created in the 20th century, philosopher, poet, playwright, combines classical tradition and literary heritage. Respecting the creativity and tradition of the classics of world and Azerbaijani literature, Bakhtiyar Vahabzadeh demonstrated a classical approach to the literary texts he created, thus keeping the literary heritage alive in modern literature. This is the integration and interpretation of the classics into the new era. New digital technologies also bring new methods and ways to the expression and dissemination of literature.

It is understood from the research that the digital transformation of literature is viewed as a process of change in terms of structure, meaning, and function. In this context, Bakhtiyar Vahabzadeh's work is analyzed as a poetic expression of various transitions, and these features are shown to emerge in a new way in the digital environment. In the empirical part, social media comments were analyzed and it was determined that readers often share the poet's verses as a commentary, evaluating him as a representative of classical literature, that is, the reader is no longer passive, but actively participates in the interpretation of the text, supports its digitization, and wishes it to be accessible. As a result, it can be said that classical poetry gains a new life in the digital environment: it becomes not just a readable text, but a part of everyday communication. In this regard, Bakhtiyar Vahabzadeh's work acts as both a literary heritage and a dynamic poetic model living in modern digital culture.

Keywords: Classical poetic discourse, tradition, heritage, digitalization, transformation.

Introduction

In scientific literature, there are unique and different definitions and meanings of classicism. Against the background of this diversity, the unambiguous criterion of classicism is its value, a style that has passed the test of time and retained its human relevance. The official online encyclopedia website of the famous “Encyclopaedia Britannica” describes classical literature as follows: "Classical literature, the literature of ancient Greece and Rome (see Greek literature; Latin literature). The term, usually spelled "classical," is also used for the literature of any language in a period notable for the excellence and enduring quality of its writers' works. In ancient Greece such a period extended from about 500 to 320 bce. The Golden Age of Rome ran from about 70 bce to 18 ce. French literature of the second half of the 17th century is considered classical, as is English literature of 1660–1714. The works produced and the critical standards that prevailed in both eras emulated those of the Classical periods in Greek and Latin, although this criterion is not an essential characteristic of a classical literature.” [7]

As can be seen, classics are important not only for a single nation, but for humanity as a whole. It is as if classical traditions play the role of a base, a foundation for literary genre and approach. We also learn from the article “Who is a Classic?” by the French writer and critic Charles Saint-Beau (1804-1869), the founder of the biographical school in literary criticism, that the concept of Classic is historically variable and has acquired different meanings in different periods. The term first emerged as a concept related to the upper class in ancient Rome, and was later applied to literature. Previously, only ancient (Greek and Roman) authors were considered classics, but over time, as national literatures were formed (Italian, French, etc.), their classics also began to appear. Although academic definitions mainly present a classic as a “regular, exemplary writer”, this approach is limited. A true classic is a writer who enriches the human spirit, discovers universal truths, remains relevant regardless of time, and creates a personal yet universally understandable style.

The goal of the word masters who created examples of classical literature was not to make a revolution at all, but rather to create harmony and balance. However, there is a subtle line here, which is that reaching excessive regularity is also unimportant.

In classical theory, the superiority of cognition (reason) over imagination and feeling has long been accepted. This approach has been dominant in Latin and especially French literature. However, in large-scale literary examples (for example, in epics and dramas), passion and emotion play a stronger role than cognition. It should be noted that cognition also dominates in the work and philosophical thought of Bakhtiyar Vahabzadeh, a prominent representative of Azerbaijani literature. According to Buffon's approach, the idea, structure and execution in a classical work should be in unity, the work should not be fragmented, and should be built on a single plan. Goethe also considered the classics alive, healthy, and strong, compared to romanticism, its unit of measurement is not time, but quality.

In general, if we look at the classics from the perspective of broad literary criticism, the classics cannot be evaluated with uniform standards, and the systematic thinking here is a product of later periods. In the modern era, the main point in looking at the classics is that the greatest geniuses are often not initially accepted, but are re-evaluated over time. And this assessment often changes depending on the historical context.

Charles Saint-Beau (1804-1869) in his article "Who is a Classic?" notes that the concept of classic is a category that must be both preserved and expanded. It is impossible to become a classic by imitating only the purity of language and the elegance of style; such an approach produces artificial results and distances itself from true creativity. "The value of the classics lies in their power to express universal human experience. From this point of view, classical literature should not be limited to the boundaries of a particular people or era. On the contrary, it should be imagined as a vast "temple" encompassing various cultures and literary traditions. Within this temple, great representatives of both Western and Eastern literature – geniuses who lived in different times and in different circumstances – come together. Such an approach allows us to understand literature as a global and timeless phenomenon and shows that great works of art establish a "dialogue" with each other, transcending peoples and centuries." [6]

Thus, the concept of classicism is an expression of aesthetic and moral values that have stood the test of time. On the one hand, it is universal, on the other hand, it has an individual character and is rediscovered by each reader. Classical works not only enrich a person aesthetically, but also have a power that reconciles him with himself and the world, creating lasting moral stability. Ali Nazim wrote: "When the classical heritage, tradition is viewed as a passed stage, an outdated era, many discoveries of generations before us remain forgotten, and these discoveries become problems that are much more difficult for future generations to understand and explain."

"The trends that emerged in the West at the beginning of the 20th century emerged from the need to destroy classical molds, from certain economic, political and social conditions, from the inner restlessness of man, from the desire to freely express himself, to change the world, from a revanchist mood against the past and traditionalism. For example, expressionism, which emerged in the first decade of the 20th century, was an expression of a reaction to capitalism and the political situation of that time."[2, 37]

The trends that emerged in the West at the beginning of the 20th century were attempts to destroy classical molds, to escape from certain economic, political and social realities, human suffering, to change the world, to speak out against the past and traditionalism. However, since the classics have already passed certain tests, they have maintained their relevance at all times, both in world literature in general and in the literature of individual nations, as well as in Azerbaijani literature. Because Man stands at the center of these literary examples. "In ancient Egyptian and Greek literature, in many examples of classical literature, in Nizami Ganjavi's "Khamsa", Rumi's "Masnavi", in Nasimi's and Fuzuli's ghazals, in the poems of Sabir, Javid, Hadi, man was presented as a supreme value, and the idea of the unity of the world was instilled as a fundamental principle." [2, 167]

Although there have been tendencies to oppose the classics at different times, over time, ideas improve, and a return to them takes place. The attitude towards the classics and the literary heritage they created can receive its true value, so that the essence and essence of their creativity can be fully understood, and the objective-historical picture of the times they lived in, as well as the national-spiritual and moral realities, are not left out of context. Let's give it to N. Jabbarli: "In my opinion, when analyzing the creativity of postmodernists, we should talk about an approach to reality rather than reality. Because both classical literature and contemporary literature (meaning those written in traditional forms) are engaged in reflecting reality. It's just that the attitudes of postmodernists and representatives of the new generation who want to be called (and also become) postmodernists towards reality are different. More precisely, they are crude and naked. Their biggest flaw is to bring their chaotic attitudes towards society and the world, their hatred and hatred to their creativity." [3, 52]

For a long time, classical poetry was perceived as operating with an unchanging, stable and closed system of rules, but it is not static, but a dynamic system. The concept of classicism is reinterpreted at all times, changing and expanding against the background of new aesthetic criteria and literary experiments and approaches. In this regard, classical poetics is not just a frozen model of the past, but a living structure that is transformed over time, developing in interaction with various literary movements. The dynamism of classical poetics is also manifested in its dialogue with various literary traditions. The process of continuous interaction between antiquity, the Middle Ages, the Renaissance and modern literature enriches the concept of classicism. As a result of this process, classical poetics can act not only as a set of certain rules, but also as an open system that stimulates new creative possibilities.

Classical poetic discourse is a style, an aesthetic and intellectual system, formed in classical literature and poetry, which, despite being repeated for centuries, can always acquire new meanings, and has a certain set of aesthetics, structure and ideas. The features of classical poetic discourse have been formed and attracted attention in different periods. According to Aristotle, order and integrity are the main features, and events, images and ideas within the work are harmoniously and purposefully interconnected. According to Mikhail Bakhtin, dialogical and multilayered meaning is important in classical poetic discourse, the text is enriched by the interaction of different voices and views. Yuri Lotman notes that the codified structure of the classical poetic style works through certain symbols, forms and aesthetic principles; it is an open system associated with cultural memory. However, the most important thing is that the seemingly rigid rules of poetic discourse are dynamic and adapt to all times.

Tradition and heritage in the work of Bakhtiyar Vahabzadeh

The poet, playwright, writer, and publicist Bakhtiyar Vahabzadeh, who played a very important role in the poetic and literary heritage of 20th century Azerbaijan, is one of the artists who kept the classical tradition alive throughout his entire work. Bakhtiyar Vahabzadeh was born on August 16, 1925 in the city of Sheki. After receiving his secondary education here, he entered the Faculty of Philology of Baku State University and graduated from it in 1947. From the same year, he began his scientific and pedagogical activity at the university and taught the history of Azerbaijani literature for many years. His creativity began with poetry from an early age. His first poems were published in the 1940s, but he became known to a wide readership with the poem "Gulustan". This work was subjected to serious criticism during the Soviet period because it reflected the ideas of national liberation, and the author faced certain pressures. Bakhtiyar Vahabzadeh is the author of poems with both lyrical and socio-political content. Homeland, freedom, language, national identity and human morality are the main themes in his work. The poet's works such as "Latin language", "Mother language" were widely distributed and highly appreciated. He also worked as a playwright and wrote a number of plays. ("Shabi Hijran", "Faryad", "Gallows", "Mugham" and others) He was not only a poet, but also a literary scholar. He conducted research on the creativity of Azerbaijani classics and wrote scientific works. He worked as a professor at the university for many years, playing an important role in the upbringing of many students. Bakhtiyar Vahabzadeh was also distinguished for his social and political activities. He was a deputy of the Milli Majlis of the Republic of Azerbaijan and actively participated in the promotion of the ideas of independence. He was awarded high honorary titles as an Honored Scientist and People's Poet. His work remains relevant today as a continuation of the national spirit, the idea of freedom and the classical poetic tradition in Azerbaijani literature.

“The relationship between predecessor and successor in literature is always relevant. Today, it is rising above the past and tradition. Understanding, feeling, and learning the predecessor is the conscientious duty and respect of the successor. In the work of Bakhtiyar Vahabzadeh, the philosophical master of words of modern Azerbaijani literature, honoring his predecessors, drawing inspiration from the masters, and reviving them as an image are among the most striking aspects.” [5, 1219]

One of the most important directions in Bakhtiyar Vahabzadeh's creativity is a specific attitude towards the classics, drawing on them and, where appropriate, criticism. However, this attitude does not remain only in the scope of a national attitude, but also has a more general and human character, since it raises the problem of Man. Here, not only the position of a nation, but also the necessary points for humanity in general come to the fore. In this regard, Chingiz Aitmatov's ideas are valuable: "Vahabzadeh's poetic thinking is national in nature. This is an exceptionally necessary condition, if you are able to be an active part of the speech of the people of which you are a child, if you are able to make your contribution to the living language architecture of your people. At the same time, Vahabzadeh's culture of poetic thinking acquires a superior essence and rises from national to universal. In this case, when you read an Azerbaijani poet, you read the world" [1] In this sense, it is necessary to understand the work of Bakhtiyar Vahabzade as a translation and interpretation of classical poetry into the modern world. Although love for the homeland and nation is the main direction in Vahabzade's work. However, this direction in no way surpasses universal love and values, from this point of view, it is even possible to call him a cosmopolitan, a citizen of the world.

B. Vahabzadeh, both in his artistic creativity and in his scientific works, was sympathetic to the classical tradition and derived from them. The poet, who repeatedly mentions the traditions of Azerbaijani folklore, prominent representatives of classical poetry - Khagani, Nizami, Fuzuli, Nasimi, Sabir, Mirza Jalil Mammadguluzadeh and others, brings historical heroes and music, which have a position in history and the development of national consciousness, into modern discourse as part of the classical heritage, presents and analyzes them in a modern approach. In Vahabzadeh's philosophical thought, the experience filtered from ancient times and the modern approach form a unity. Feeding on predecessors and drawing on folk literature examples form the basis of his poetic philosophy. However, this is not a transfer, but a striving for innovation by giving an individual-human approach to the essence. Human cognition forms a specific approach to concepts from the moment it begins to perceive life and the world. This understanding in many cases has an individual, individual-psychological, ethnopsychological and human character. Although human, individual, individual-psychological approaches create a separate impression in themselves, they are also related to ethnopsychology in their essence. The attitude towards opposites arises from their functionality and situational reaction. The loading of spiritual content on perceived concepts both distinguishes peoples and ethnic groups from each other and connects them to each other. In this sense, in Bakhtiyar's work, the classical and classicized literary and historical heritage is also presented with archetypes.

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The main archetypes of classical literature can also be seen in the work of B. Vahabzadeh. The hero archetype (Babek in Vahabzadeh's play "The Gallows Tree", Gur Shad in the play "The Sword That Cuts Us" or "The Goyturks") attracts attention as an image that overcomes difficulties and goes through trials in epic epics and tragedies. Also, the wise old man or teacher archetype, as an image that gives knowledge and direction, is important in the interpretation of real-historical personalities, literary figures and archetypes of the classical tradition in modern literature, as in the image of Sabir in the poem "Aghlar Guleghan" dedicated to poet Mirza Alakbar Sabir, the image of poet Sahhat, the image of poet Muhammad in the poem "Shabi-hijan" dedicated to Fuzuli, and the image of Dede Gorgud, who is often mentioned in his poems. The traitor or enemy archetype, which is one of the most important archetypes of classical literature, is a common issue in the literature of all peoples of the world as a force that creates conflict. The most important nuance of the struggle is revealed in the collision created with the images of the enemy. In this sense, the same motifs and archetypes are given place in the work of Bakhtiyar Vahabzadeh.

Starting from ancient literature, the archetype of the road is one of the traditional motifs considered to be eternal in the literature of the medieval world and classical East. The archetype of the road is not only about the distance covered physically. The inner world, spiritual development, and mental activity of the character are also important here. Along with the dynamics of the plot of the created heroes, the crises in their inner world, contradictory thoughts, and spiritual states arising from the unity of opposites lead them to spiritual development, in other words, a journey into oneself, into oneself, which leads to progressive changes in the heroes, or natural defeat. In Vahabzadeh's work, heroes and characters corresponding to this archetype are also created in most of the characters. In this sense, the characters of Qara Khagan and Dulu Khan in his play "The Sword That Cuts Us" or "The Goyturks" are interesting. The changes that occur in their thinking over time bring both Qara Khagan and Dulu Khan to truth and justice. However, here the spiritual journey manifests itself differently in both characters. "The Black Khagan's understanding of the truth comes late, it is already too late for everything, his possession of the Great Turk blood reveals his pride, he stains the sword he owns with his own blood. The fact that the Black Khagan takes his punishment with his own hands is perceived as his return to the right path, dramaturgically the event does not reach the level of tragedy; he is not killed by the main character. We see the same motif with Dulu Khan. He also learns from his mistakes, wants to kill himself with the sword he took without worthiness, those who forgive and understand him prevent this murder. This can also be characterized as a kind of purification. Dulu Khan is also a character in development, with this the author expresses the possibility of learning from mistakes, that genetic memory speaks sooner or later." [5,490]

Humanities and digitalization in the modern era

In the modern world, digitalization is observed in all fields as a result of the development of science and technology, and the humanities and literature are not left out of it. “As we look to the future, literature is no longer confined to printed pages but is evolving into dynamic, multimedia experiences, challenging both readers and writers to engage with stories in innovative ways. The future of literature will be more inclusive, interactive, and deeply integrated with technology.” [4]

Technology has revolutionized the creation, writing, access, and interaction of written fiction. The widespread use of technology and e-books and audiobooks has made literature more accessible and engaging, enabling the interactive presentation of fiction on digital storytelling platforms. Digital tools allow authors to experiment with multimedia elements, combine text with audio, video, and interactive features that enhance the reading experience, and reach readers and listeners more quickly. The interdisciplinary nature of digital technologies also encourages collaboration between literary scholars, coders, and data analysts, enriching literary research with new perspectives and methodologies.

Digitization expands the collaboration between literary studies and technology in the humanities, creating new ways to understand texts through data visualization. As technology advances, the reality possibilities of literature expand, and e-books, audiobooks, and e-readers, etc., comfortably connect with their readers and listeners on various platforms.

The concept of transformation

In the era of digitalization, transformation has become one of the current concepts (Latin transformare - "to change its shape"), meaning that any system, object or concept changes not in form, but in essence, gaining a new quality. Now, the transformation and transformation of literature, like in other fields, is one of the priority points. Transformation in literature is realized in ways such as changing the form, genre and means of expression of the text, and restructuring classical poetic systems in a new context. That is, the forms do not just change, their delivery and function are also optimized, moving to another level.

Digital transformation in literature is the process of adapting classical poetic discourse to the digital environment, re-forming its structure, expanding its functionality and enriching new forms of expression. In this

process, the text is not only transferred from the physical book to the screen, but also the structure, perception and interpretation methods of the work change. Digital literature is also a data source, an object of analysis, and an opportunity for interactivity. While in the classical model of literature the reader is in a passive position, in literary works integrated into a digital platform the reader is active, able to play the role of a participant-partner, interpreter, and sometimes even co-author.

Integration of Bakhtiyar Vahabzadeh's legacy into a digital platform and a modern reader

Since Bakhtiyar Vahabzadeh's work combines classicism with modernism, tradition with modernity, past with future, heritage with innovation, its interpretation in the digital environment is also easily solved. Especially on social network accounts, platforms such as YouTube and Facebook, the reviews written about Vahabzadeh's life, activities, biography, and individual examples of his work generally comment on the modern reader's attitude to him from various angles despite the change in time. The reactions to Bakhtiyar Vahabzadeh's work on digital platforms show that the reader is no longer just a perceiver of the text, but also a subject actively participating in its interpretation. The comments posted on social media platforms prove that literary discourse has become democratized and individual experiences have become collective meaning.

When searching for the title "Bakhtiyar Vahabzadeh" on the YouTube platform, hundreds of short and multi-minute video materials come to the fore. These materials cover both his biography, creative examples, and the works he has performed. An analysis of the reader-viewer-listener-interpreter comments written on these types of posts shows that reader reactions are mainly emotional, national-identical, and literary-aesthetic in nature.

In the era of the reconstruction of classical poetic discourse in the digital environment by the reader-interpreter, we observe that on platforms, the poet, who is considered a poet of the people, a truth-seeker, a great son of the Turkic world, and a source of pride, is also considered a spiritual continuation of classical literature in the modern era, on a par with artists such as Nizami and Fuzuli: “In my opinion, there is no step behind Nizami and Fuzuli. Nizami, Fuzuli, and Bekhtiyar Vahabzade are also great artists and poets of this people...”, or “You will live just as the Nizamis and Nasimis lived, poet, be sure of that..”, etc.

In a significant part of the comments, the poet is presented and analyzed as a philosopher, and sometimes he is called “the second philosopher poet of Azerbaijan after Nasimi.” These kinds of thoughts can be seen more in the comments written on the video material of his philosophical poems. The digital reader also evaluates Vahabzadeh's work, which has mastered ancient Eastern and mystical philosophy, not only in an aesthetic, but also in a philosophical-spiritual context when expressing opinions. In reader reactions, the author is idealized by associating it with concepts such as "truth", "sect" and "culture", which shows that he is presented as a spiritual authority in the digital environment. That is, the reader-listener does not just accept information ready-made, but also gives it meaning and turns the author into an ideological symbol. The reader is able to apply a psychological and philosophical approach to the text, the digital reader is already a subject of analytical interpretation. Analysis of social media comments shows that Bakhtiyar Vahabzadeh's work is perceived in the digital environment not only on an emotional, but also on a philosophical and analytical level. Readers interpret the socio-political and spiritual problems in the author's works in the context of the conflict of emotion and rationality, and at the same time present him as one of the top figures of the national literary canon. This approach shows that classical poetic discourse is becoming relevant again in the digital environment and is being adopted by the younger generation. This shows that the digital reader does not approach the issue only from an emotional aspect, but also understands, analyzes and relates to the literary text.

It is also interesting that the reader, moved by the video material, quotes the poem that left a mark on his memory and impressed him with Bakhtiyar Vahabzadeh's work. This shows that classical poetic texts function not only as aesthetic objects in the digital environment, but also as active communicative tools. The fact that readers use the poet's verses to express their emotional and spiritual states demonstrates that these texts are fixed in the collective memory and have become an integral part of everyday digital discourse. On the platforms, comments such as "Where there is no one else but oneself, a person forgets that he is a human being..." and "What a beautiful line: "...if you have a confidant who knows your troubles..." originated from Bakhtiyar Vahabzadeh's own work.

We would like to emphasize in particular that the social media comments used in the study were analyzed as empirical material, in accordance with ethical principles, the users' data were anonymized, names were not given, and specific links were not provided. The comments were taken on a purposeful basis, and only reactions related to the text and carrying content were included in the study.

Conclusion

In conclusion, it is worth noting that the study shows that digital transformation in literature, along with technological advances, leads to a structural and functional restructuring of classical poetic discourse. The study of Bakhtiyar Vahabzadeh’s work shows that literary texts in the digital domain play active communicative and interpretive roles, rather than remaining passive objects of perception. Empirical studies conducted on social media comments show that readers not only read classical poetry, but also repeat it, expressing their spiritual and emotional states through the poet’s poems. This shows that the text has become an important component of digital discourse and is strengthened as a component of collective memory.

The study shows that digital transformation in literature, along with technological advances, leads to a structural and functional restructuring of classical poetic discourse. The study of Bakhtiyar Vahabzadeh’s work shows that literary texts in the digital domain play active communicative and interpretive roles, rather than remaining passive objects of perception. Empirical studies of social media commentary show that readers not only read classical poetry, but also retell it, expressing their own spiritual and emotional states through the

poet's poems. This suggests that text has become an important component of digital discourse and is becoming entrenched as a component of collective memory.

Digital technological development does not move away from the classics, classical literature and those who keep it alive use innovative opportunities to "simplify" and make classical discourse accessible, allowing it to spread more widely and gain new life in the digital environment.

Vahabzadeh's work acts not only as a classical poetic system, but also as a dynamic poetic model that provides a transition between various historical and cultural stages. When Bakhtiyar Vahabzadeh's work is analyzed from the perspective of "transitional poetics", it becomes clear that his poetic system reflects various transformation processes on the historical, psychological and aesthetic levels. These processes acquire a different content in the digital environment and ultimately lead to the transformation of classical poetic discourse into an interactive and communicative form.

References

1. Akhundlu, Y. (1998). Istiglal poets. Elm Publishing House.
2. Akimova, E. (n.d.). Contemporary poetry and literary trends [PDF]. https://kitabxana.net/files/books/file/1532796825.pdf
3. Jabbarli, N. (2006). New generation literature. Elm.
4. Kolhal, R. (n.d.). Digital humanities and the future of literature. https://dypsst.dpu.edu.in/blogs/digital-humanities-literature-future
5. Mustafayeva, M. (2022). As a carrier of the national spirit in Bakhtiyar Vahabzadeh's poem "Sheb-Hijran". In VI International Scientific Conference of Young Researchers dedicated to the 99th anniversary of the birth of our national leader Heydar Aliyev. Baku Engineering University.
6. Sainte-Beuve, C. A. (n.d.). Who is the classic? https://www.edebiyyatveincesenet.az/edebiyyat/item/7404-klassik-kimdir-sharl-sent-boev
7. Classical literature. (n.d.). Britannica. https://www.britannica.com/art/classical-literature

INTEGRATION OF COGNITIVE-LINGUISTIC AND INSTITUTIONAL MODELS IN THE DEVELOPMENT OF DOMESTIC TOURISM IN KAZAKHSTAN

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Abstract:
This essay examines the impact of domestic tourism on society and the economy in Kazakhstan. Domestic tourism is not merely a form of leisure; it also plays a significant role in stimulating demand, balancing regional income, creating new employment opportunities, and strengthening social cohesion. Based on official statistics, the growth of tourist flows, the development of accommodation infrastructure, and the expansion of tourism services are demonstrated. Domestic tourism contributes to the preservation of national culture, the promotion of historical heritage, and the deepening of citizens' understanding of their country, thereby supporting sustainable regional and societal development.
Keywords: domestic tourism, socio-economic significance, national sustainability, regional development.

Introduction

Domestic tourism in Kazakhstan has become a crucial component of contemporary society and the national economy. This sector is not limited to leisure and recreational services; it significantly contributes to regional economic development, social stability, and the preservation of national culture. The development of domestic tourism enhances tourist demand, reduces income disparities across regions, creates new employment opportunities, and strengthens local social networks.

Research indicates that the effectiveness of domestic tourism is measured not only by economic indicators but also by the cultural, historical, and spiritual experiences of tourists. For instance, visits to the memorial sites and literary museums dedicated to Abai and Shakarim Kudaiberdy allow tourists not only to engage in geographical mobility but also to internalize national cultural codes, historical consciousness, and spiritual values. This cognitive-linguistic approach broadens the tourist's cognitive and emotional experience, demonstrating that tourism is not solely about aesthetic or recreational effects but also encompasses a cultural and knowledge-based dimension.

Moreover, the institutional aspects of domestic tourism are equally significant. The development of tourism infrastructure—including roads, accommodation facilities, sanitation standards, and digital services—and the quality of tourism services directly influence the economic efficiency of tourist experiences. In Kazakhstan, state programs and private sector initiatives, such as those offered by **TEZ TOUR** and **Palmatour**, contribute to the organization of tourist flows and enhance the quality of tourism products.

From this perspective, the development of domestic tourism extends beyond mere economic gain, supporting the preservation of national cultural heritage, the cultivation of historical awareness, and the promotion of citizens' understanding of their country. Integrating cognitive-linguistic and institutional models in Kazakhstan's domestic tourism sector enables a comprehensive realization of the socio-economic and cultural significance of the tourist experience.

Main Section

Domestic tourism in the contemporary economy is regarded not merely as a form of leisure, but as a significant instrument that socially and economically integrates the national space. According to the Concept for the Development of the Tourism Sector in the Republic of Kazakhstan for 2023–2029, tourism is recognized as one of the priority sectors of the national economy. This highlights that the development of this sector is directly associated with infrastructure modernization, service quality improvement, and regional policy implementation. Official statistics indicate that in the first nine months of 2024, the number of domestic tourists in Kazakhstan reached 6 million, reflecting a clear increase in internal demand. Moreover, the National Bureau of Statistics reports that by the end of 2025, the number of accommodation facilities reached 4,482, while the total number of serviced visitors amounted to 10,087.1 thousand. These figures demonstrate that domestic tourism has evolved from a seasonal phenomenon into a stable sector that generates continuous economic turnover [1].

The aim of this study is to scientifically analyze the socio-economic significance of domestic tourism development through the integration of cognitive-linguistic and institutional models. The objectives include demonstrating the impact of domestic tourism on employment, small businesses, regional balance, social cohesion, and national identity; comparing domestic and international research findings; and assessing the current situation in Kazakhstan. The relevance of the study is emphasized by the increasing role of domestic tourism as a stabilizing factor in the domestic market,

especially under conditions of external economic instability and global crises.

The methodology employed in this study includes comparative analysis, review of official statistics, and discursive and interpretative analysis of scientific literature. The novelty of this research lies in examining domestic tourism not merely as a service sector, but as a complex phenomenon that serves as a generator of social capital, spatial balance, and regional income. The research question focuses on elucidating the interrelationship between the economic impact and social influence of domestic tourism. The subject of the study encompasses the socio-economic functions of domestic tourism, while the scope covers the current development of domestic tourism in Kazakhstan and the international scientific approaches applied for its evaluation.

The central thesis of this study is as follows: domestic tourist mobility within the country is not merely a form of leisure activity, but also a tool that increases internal demand, redistributes income, and mitigates economic disparities among regions.

According to Kazakhstan's Tourism Satellite Account, domestic tourism consumption in 2023 increased by 32.2% in nominal terms, reaching 2,759.6 billion KZT. The same report indicates that expenditures related to domestic tourism rose from 1,595.2 billion KZT in 2022 to 2,233.7 billion KZT in 2023. This growth demonstrates the direct multiplicative effect of domestic tourism on hotels, food services, transportation, retail, and cultural activities. Therefore, domestic tourism is not merely a sector generating profits for travel companies; it represents an economic system that stimulates revenue circulation across multiple interconnected sectors.

According to domestic researchers, the primary advantage of domestic tourism lies in its regional characteristics. J. N. Orymbasar, K. K. Nurasheva, and L. P. Moldashbayeva, analyzing domestic tourism across Kazakhstan's regions, emphasize that in order to enhance the sector's contribution to gross value added, it is necessary to address infrastructure development, transport accessibility, service quality, and local branding issues [1]. This perspective is highly significant, as the effectiveness of domestic tourism is not measured merely by an increase in tourist numbers; its true value lies in how long the incoming tourist flows generate revenue within the local economy.

K. P. Mussina, in a bibliometric analysis of literature on domestic tourism development, notes that current research primarily focuses on themes such as sustainability, regional growth, digitalization, and tourist behavior [2]. Such conclusions indicate that domestic tourism has evolved beyond the traditional excursion model into a multifaceted socio-economic system.

However, a uniform positive perspective is not present in the discourse. Some researchers note that despite the high potential of domestic tourism, its effectiveness is hindered by weak infrastructure, seasonality, service inequalities, and limited digital accessibility. A. T. Tleuberdinova and colleagues, analyzing the development of tourism in rural areas, emphasize that if roads, communication networks, engineering infrastructure, and entrepreneurial ecosystems are underdeveloped, the economic impact of tourism tends to disperse at the local level [3]. B. Ongaeva, K. Mussina, and A. Mukanov, applying the concept of "soft tourism" to Kazakhstan's regions, argue that compared to mass tourism, responsible, slow, and nature-integrated tourism has higher social significance [4]. From this perspective, evaluating domestic tourism solely based on quantitative indicators is insufficient; its qualitative characteristics, the impact on local communities, and ecological sustainability must also be considered.

Moreover, scholarly attention to domestic tourism in Kazakhstan has intensified in recent years. Domestic studies conducted between 2022 and 2026 increasingly address regional development, agrotourism, digitalization, ecotourism, and tourist branding. Z. Toleubayeva's 2025 econometric study identifies economic and infrastructure-related variables as key factors influencing tourism development in Kazakhstan [5]. In the international scientific discourse, domestic tourism is similarly recognized as a pillar of social resilience. K. Kifworo and K. Dube, analyzing post-pandemic conditions in African countries, demonstrate that domestic tourism acted as an adaptive mechanism supporting the economy during periods of weakened international flows [6]. The OECD's 2024 review on tourism policy also emphasizes the critical role of coordinated, inclusive, and sustainable policies in tourism recovery [7]. Some scholars, such as K. Kronenberg, argue that domestic tourism generates lower foreign exchange compared to international tourism, and therefore its macroeconomic weight may be limited. However, this perspective is incomplete, as the core value of domestic tourism lies not in attracting foreign currency but in retaining national income domestically, redistributing revenue across regions, and supporting local employment. K. Kronenberg and colleagues further demonstrate that tourism's impact is observable not only at the macroeconomic level but also at the level of specific professions and local territories [8]. U. Bob and A. al-Ruwaifah's research confirms shifts in traveler behavior, with individuals increasingly favoring nearby, safe, meaningful, and flexible domestic destinations [9]. This trend indicates that domestic tourism is no longer merely an alternative option but is becoming central to contemporary tourist culture. L. Yuzhnik Rotar's study also demonstrates a positive correlation between tourism and employment [10]. From an evaluative perspective, the perception of domestic tourism as "weak" often arises from assessing it solely through an export-oriented lens; however, from a social-economic standpoint, the sector delivers far more substantial outcomes. This underscores that the success of domestic tourism does not depend on random cultural curiosity but on concrete institutional and infrastructural prerequisites. Internationally, D. Varadzhakova interprets domestic tourism through consumer choice, emotional engagement, and accessibility factors [10].

Table

Dilemmas and Indicators of Domestic Tourism Development in Kazakhstan

Dilemma / Challenge	Indicator / Evidence	Commentary
Tourism as leisure vs. economic driver	2023 domestic tourism consumption +32.2% to 2,759.6 bn KZT; tourism-related expenditures 2,233.7 bn KZT	Shows the sector's multiplier effect beyond leisure, affecting hotels, transport, catering, retail, and culture
Regional potential vs. infrastructure gaps	Accommodation facilities: 4,482; Visitors: 10,087.1k; Issues: roads, engineering, service quality	Infrastructure constraints limit full economic potential, especially in rural areas
Quantitative growth vs. qualitative impact	Focus on social capital, community engagement, environmental sustainability	Emphasizes that tourist numbers alone do not capture real socio-economic benefits
Mass tourism vs. responsible "soft tourism"	"Soft tourism" concept prioritizes slow, nature-compatible travel	Highlights social and ecological sustainability as part of domestic tourism value
International perspective vs. national retention	Low foreign exchange vs. local income retention	Domestic tourism strengthens national income redistribution and regional employment rather than foreign currency inflow
Traditional excursion model vs. multifaceted system	Research on digitalization, sustainability, tourist behavior, regional branding	Indicates evolution toward complex socio-economic system beyond sightseeing

Research Methodology. Integration of cognitive-linguistic and institutional models in the development of domestic tourism in Kazakhstan. Current tourism research reveals two primary paradigms: the first is a systemic-institutional approach, and the second is a consumer-oriented cognitive-experiential approach. Domestic studies in Kazakhstan tend to focus on tourism infrastructure, management systems, logistics, and institutional regulation, whereas international literature prioritizes tourist behavior, emotional experience, and the perceived value derived from travel. Accordingly, the most effective model for Kazakhstan involves synthesizing these two approaches. On one hand, the basic tourism infrastructure—road quality, service standards, digital navigation, and sanitary-hygienic conditions—must be ensured at a high level. On the other hand, the tourist experience should extend beyond mere physical comfort, encompassing cognitive, emotional, and cultural dimensions. In this context, the Almaty–Semey–Zhidebai–Konyr Auliye route can serve as a model for a spiritual-cognitive tourism itinerary. This route encompasses multiple layers of the tourist experience: geographical movement (a 1,128 km journey from Almaty to Semey), engagement with historical and cultural sites (e.g., the literary-memorial museum of Abai in Zhidebai), immersion in personal-spiritual spaces (the heritage of Abai Kunanbayuly and Shakarim Kudaiberduly), and elements of sacred tourism (the Konyr Auliye cave). Such a route is not merely a tourist product; it constitutes a complex cultural experience that revitalizes national cultural memory, deepens historical consciousness, and fosters spiritual cohesion. Within this framework, the programs of tourism companies such as Palma Tour (formerly TEZ TOUR) are also noteworthy. Their practices illustrate the integration of service quality and customer experience in the organization of domestic tourism products. Theoretically, this issue is explored in depth in the works of G. H. Tulekova. In her study, "National Code and the Cognitive Significance of Abai's Great Works", the national code is described as a complex semiotic system that preserves the spiritual experience, worldview, and historical memory of a people. This perspective allows for a novel interpretation of tourism discourse within the framework of cognitive linguistics.

Specifically, tourism discourse based on cognitive linguistics (Cognitive Linguistics of Tourism Discourse) examines processes such as: the tourist's perception and understanding of the world through language (cognitive modeling);

- the interpretation of cultural codes through literary texts;
- the emotional and aesthetic impact generated during the travel experience.

This approach positions domestic tourism not merely as an economic phenomenon but as a form of cultural-cognitive and spiritual communication. For instance, B. Nassenov, drawing on archival data, emphasizes the need to reassess historical truths related to Shakarim Kudaiberduly. His research highlights the importance of scientific accuracy and evidence-based information in tourist routes. This, in turn, enhances the reliability and cognitive value of tourism discourse. This constitutes a key innovation of the present study.

Diagram 1. The Impact Chain of Domestic Tourism

1.Growth of domestic tourist flows

2.Increased demand for service sectors *(accommodation, food services, transportation)*

3.Growth in SME revenues

4.Strengthening of local employment

5.Development of regional budgets and infrastructure

6.Increased interest in cultural and natural landmarks

7.Reinforcement of national unity and social cohesion

Domestic tourism functions not only as an economic activity but also as a mechanism that strengthens national resilience in the face of external shocks. This three-dimensional understanding allows domestic tourism to be evaluated not merely as a leisure industry but as an element of national stability. Limiting domestic tourism to economic activity is insufficient, as it also serves as a space that revitalizes national cultural memory, deepens historical consciousness, and reinforces spiritual cohesion.

In this context, the research of G. Tulekova is particularly significant. In her work *"National Code and the Cognitive Significance of the Great Abay's Works"*, the concept of the national code is considered a value system that preserves the spiritual experience, worldview, and historical memory of the people. This perspective enables a deeper understanding of the nature of domestic tourism. Travel within the country is not merely a geographical movement; it is a process that reconnects individuals with national heritage, historical figures, literary memory, and the cultural space.

From this viewpoint, sacred sites associated with Abay, literary and memorial museums, historical routes, and cultural landscapes enhance the cognitive and educational content of domestic tourism. Consequently, the social significance of domestic tourism is also reflected in citizens' deeper perception of their homeland's spiritual and cultural space [11].

G. Tulekova's research on the nominal phrases and conceptual structures in the works of Abay and Shakarim, approached through the Baitursyn method, expands the theoretical foundation for reinterpreting cultural content. This approach demonstrates an effective way to convey national texts to contemporary audiences in a comprehensible and systematic manner. Such a framework is particularly significant for cultural tourism, as a tourist must not only view a particular site but also understand its underlying historical and spiritual significance.

Muhametkali, Bolatova, Tulekova G., and colleagues describe intertextuality as a mechanism for dialogue between cultures and philosophical traditions. This perspective deepens the cultural function of domestic tourism: the tourist space is not merely infrastructure or a leisure zone but a symbolic environment where texts, ideas, historical memories, and national values intersect. Consequently, incorporating the heritage of spiritual figures such as Abay, Shakarim, and Baitursynuly into tourist routes enhances both the social impact and the cognitive quality of domestic tourism [12], [13], [14].

Conclusion. In conclusion, the socio-economic significance of domestic tourism is multifaceted: It preserves and revitalizes the national cultural code,

It enhances the historical consciousness of society, It stimulates economic activity, It supports local entrepreneurship.

Therefore, strategies and projects aimed at developing domestic tourism should not be limited solely to infrastructural improvements. They must also consider the cognitive, emotional, and cultural experiences of the tourist.

Dimension	Dilemma / Challenge	Indicator / Evidence	Commentary
Economic	Tourism as leisure vs. economic driver	2023 domestic tourism consumption +32.2% to 2,759.6 bn KZT; tourism-related expenditures 2,233.7 bn KZT; accommodation: 4,482; visitors: 10,087.1k	Domestic tourism stimulates income circulation across hotels, catering, transport, retail, and cultural sectors; creates jobs; supports small businesses and infrastructure
Social	Quantitative growth vs. qualitative impact	Research on employment, regional balance, citizen connectivity, small business support	Tourist numbers alone do not capture the full social benefit; tourism enhances societal cohesion, civic engagement, and regional inclusion
Cultural / Cognitive	Mass tourism vs. meaningful cultural experience	Integration of Abay, Shakarim, Baitursynuly heritage; literary-memorial museums; historical routes; cultural landscapes; intertextuality as dialogue	Domestic tourism reconnects visitors with national heritage, spiritual figures, and cultural memory; promotes historical consciousness and national identity; emphasizes cognitive, emotional, and cultural experience
Sustainability / Strategic Integration	Infrastructure gaps vs. sustainable growth	Need for roads, service quality, digitalization, "soft tourism" practices, sustainable development principles	Effective domestic tourism requires combined improvement of infrastructure, service, digital access, and eco-friendly practices; balances economic growth with cultural and social impact

Conclusion. In summary, the development of domestic tourism represents a crucial avenue for diversifying the national economy, promoting balanced regional development, and strengthening societal cohesion. Its economic significance is manifested through income generation, employment, support for small businesses, and infrastructure development, while its social significance is reflected in the engagement with cultural heritage, territorial awareness, civic connectivity, and national identity. Research and official statistics indicate a tangible growth of domestic tourism in Kazakhstan; however, for a qualitative surge, infrastructure, service quality, digitalization, and sustainable development principles must be integrated. Thus, domestic tourism today is not merely a leisure-oriented sector but a powerful mechanism for socio-economic revitalization.

References

1. Orymbasar, Zh. N., Nurasheva, K. K., & Moldashbayeva, L. P. (2025). Tendencies and prospects of domestic tourism development in the regions of Kazakhstan. *Economic Series of the Bulletin of L.N. Gumilyov ENU*, (1).
2. Mussina, K. P. (2025). Bibliometric analysis of domestic tourism development trends and regional growth factors. *National Economy: Development Vectors*, (1).
3. Tleuberdinova, A. T., et al. (2022). Infrastructural security and development of tourism in rural areas of Kazakhstan: Challenges and prospects. *National Economy: Development Vectors*.
4. Onayeva, B., Mussina, K., & Mukanov, A. (2025). Soft tourism as a tool for sustainable development of destinations in the regions of Kazakhstan. *Economic Series of the Bulletin of L.N. Gumilyov ENU*, (3), 397–415. https://doi.org/10.32523/2789-4320-2025-3-397-415
5. Toleubayeva, Z. (2025). Econometric analysis of key factors affecting domestic tourism development in Kazakhstan. *Eurasian Journal of Economic and Business Studies*.
6. Kifworo, C., & Dube, K. (2023). A review of domestic tourism resilience research agenda in Africa post-COVID-19. *GeoJournal of Tourism and Geosites*, 51(4, special issue). https://doi.org/10.30892/gtg.514spl15-1170
7. OECD. (2024). *Tourism trends and policies 2024*. Paris: OECD Publishing.
8. Kronenberg, K., et al. (2022). The socio-economic impact of regional tourism. *Journal of Sustainable Tourism*.
9. Bob, U., & Alrwajfah, A. (2024). Understanding changing patterns in travel behaviour to promote domestic tourism recovery and sustainability. *Development Southern Africa*.
10. Varadzhakova, D. (2025). Consumers' attitudes toward domestic leisure tourism. *Tourism and Hospitality*, 6(2).
11. Tulekova, G. (2020, January 12). National code and the cognitive significance of the Great Abay's works. *Journal Article*.
12. Tulekova, G. (2019, February 6). Reviving nominal phrases and conceptual structures in Abay and Shakarim's works using the Baitursyn method. *Journal Article*.
13. Mukhametkali, A., Bolatova, G., Tulekova, G., & Argynbayeva, M. (2025). Intertextuality as a mechanism of dialogue between cultures and philosophical traditions: A comparative study of Thomas Eliot's and Bakytzhan Momyshuly's works. *Theory and Practice in Language Studies*, 15(9). https://doi.org/10.17507/tpls.1509.04
14. Palma Tour. (n.d.). *Vnutrennij turizm*. Retrieved April 6, 2026, from https://www.palma-tour.ru/vnutrennij-turizm?utm_source=chatgpt.com

ЛЕКСИКО-СЕМАНТИЧЕСКАЯ КЛАССИФИКАЦИЯ ТЕРМИНОВ ЭКОЛОГИИ ВОЗДУХА В РУССКОМ ЯЗЫКЕ

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LEXICO-SEMANTIC CLASSIFICATION OF AIR ECOLOGY TERMS IN THE RUSSIAN LANGUAGE

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Аннотация

В статье рассматривается лексико-семантическая структура терминов, относящихся к экологии воздуха. Целью исследования является систематизация и классификация специализированной лексики данной предметной области с опорой на семантические и морфологические признаки. Проведённый анализ позволил выделить ключевые семантические группы терминов, отразить их функционально-понятийные связи и определить степень абстрактности и оценочности лексических единиц. Особое внимание уделено выявлению логико-семантических цепочек, отражающих процессы загрязнения, мониторинга, биохимических реакций и правового регулирования. Результаты исследования способствуют более глубокому пониманию структуры терминологической системы экологии воздуха и могут быть использованы в лексикографической, образовательной и прикладной экологической практике.

Abstract

The article examines the lexico-semantic structure of terms related to air ecology. The aim of the study is to systematize and classify the specialized vocabulary of this domain based on semantic and morphological features. The analysis identifies key semantic groups of terms, reveals their functional and conceptual interrelations, and defines the levels of abstraction and evaluative connotation within the vocabulary. Particular attention is given to the identification of logical-semantic chains that reflect processes such as pollution, monitoring, biochemical reactions, and legal regulation. The results contribute to a deeper understanding of the terminological system of air ecology and can be applied in lexicographic, educational, and practical environmental contexts.

Ключевые слова: экология воздуха, терминология, семантическая классификация, лексический анализ, экологическая лексика.

Keywords: air ecology, terminology, semantic classification, lexical analysis, environmental vocabulary, terminological system.

Экологическая терминология представляет собой важный пласт научной лексики, отражающий специфику взаимодействия человека и окружающей среды. В условиях нарастающих проблем загрязнения воздуха особую актуальность приобретает изучение языковых средств, используемых для обозначения явлений, процессов и объектов, связанных с атмосферой. Термины экологии воздуха в русском языке отличаются высокой степенью семантической насыщенности, структурной вариативностью и междисциплинарностью, что требует их системного лингвистического анализа.

«Развитие экологической лексики отражает развитие взглядов на данную предметную область от неясных одиночных представлений к точной классификации объектов. Это проявляется… в тенденции перехода значений слов от неточных к конкретным точным значениям» [2].

Тема и цель исследования. Тема исследования – семантические особенности терминов экологии воздуха в русском языке. Цель исследования – выявить и описать основные семантические характеристики терминов, относящихся к экологии воздуха, на основе лингвистического анализа их структуры, значений и тематической принадлежности.

Методология исследования. Для достижения поставленной цели применяются следующие методы: 1. Метод контекстного анализа — изучение термина в его семантическом окружении, а также в текстах нормативных документов и научных источников; 2. Метод компонентного анализа — выделение ядерных и периферийных компонентов значения терминов: например, в термине "загрязнение воздуха" ядром является "загрязнение", а модификатором — "воздуха";

Материалом исследования послужил обширный перечень экологических терминов (685), относящиеся к различным аспектам экологической лексики, включая терминологию, связанную с атмосферным воздухом.

Основные результаты исследования. Лексика экологии воздуха в русском языке представляет собой специализированную подсистему научных терминов, отражающую состояние атмосферы, процессы её загрязнения, очистки и охраны. Термины данной области обладают рядом характерных семантических особенностей, что подтверждается анализом представленного корпуса терминов. Рассмотрим конкретные примеры:

1. Атмосферные компоненты и свойства. Данная группа включает термины, описывающие

физические и химические характеристики атмосферы, её стратификацию, лучевое воздействие и биохимические параметры. Примеры: *атмосферная инверсия*, *стратификация атмосферы*, *ионизирующее излучение*, *электромагнитное излучение*, *аэробы*.

2. Загрязнение воздуха и типы загрязнений. Эта группа охватывает термины, связанные с различными формами антропогенного и природного загрязнения воздуха: *загрязнение атмосферное*, *загрязнение химическое*, *загрязнение световое*, *озоновая дыра*, *предельно допустимый выброс*, *концентрация предельно допустимая*.

3. Контроль и очистка воздушной среды. Включает термины, характеризующие методы, стандарты и подходы к мониторингу и нормированию состояния воздушной среды: *очистка воздуха*, *экологическое нормирование*, *мониторинг глобальный*, *экологическая экспертиза*, *норма выброса*. Согласно работам Лысенко (2019), «структуризация терминов мониторинга позволяет упорядочить понятийный аппарат в сфере экологической безопасности».

4. Газообмен и биохимические процессы. Термины этой группы отражают природные циклы, в которых воздух и содержащиеся в нём газы играют важную роль: *азотфиксация*, *фотосинтез*, *газообмен*, *биохимическое потребление кислорода*, *аэробные организмы*, *биогенные элементы*. Эти понятия используются при описании биосферных процессов и в рамках модели круговорота веществ в экосистемах.

5. Биотические реакции на воздушную среду. Группа включает термины, обозначающие адаптации живых организмов к параметрам воздуха, включая свет, температуру и влажность: *гелиофильные организмы*, *пойкилотермные организмы*, *фотопериодизм*, *хронобиология*, *суточные ритмы*, *омброфиты*. «Изучение адаптаций к воздушной среде способствует пониманию закономерностей экологической пластичности и приспособлений» (Карасев, 2020).

6. Правовые и природоохранные аспекты. Охватывает терминологию, связанную с правовым регулированием, международными инициативами и защитой атмосферной среды: *зона экологического бедствия*, *государственная экологическая экспертиза*, *программа юнеско "человек и биосфера"*, *оценка воздействия на окружающую среду*, *санитарно-защитная зона*.

«Термин как носитель определенного объема знаний — важнейший инструмент, как теоретического мышления, так и практической работы. Если суть и объем термина ясно очерчены, то он становится средством как выявления сходных феноменов в массе экологического материала, так и уточнения и углубления понимания самого определяемого явления» [3].

Термины часто структурированы так, чтобы отражать логические цепочки:

источник → процесс → результат → последствия. Например: антропогенное воздействие → загрязнение воздуха → повышение концентрации оксидов → риск заболеваний. Значительная часть терминов, относящихся к экологии воздуха, характеризуется выраженной оценочной окрашенностью, что свидетельствует о высокой степени социальной значимости обозначаемых ими явлений. В лексике данной области широко представлены как термины с негативной коннотацией, так и нейтральные или позитивные номинации.

К числу **негативно окрашенных терминов** относятся: *токсичные вещества*, *экологическая катастрофа*, *экологический кризис*, *глобальное загрязнение*, *загрязнение атмосферы*, *тепловое загрязнение*. Эти единицы указывают на опасные для человека и окружающей среды процессы и состояния, несущие угрозу экологическому равновесию.

В противоположность этому, **позитивные и нейтральные термины**, такие как *очищенная вода*, *экологическая безопасность*, *чистый воздух*, *норматив допустимой концентрации*, акцентируют внимание на мерах защиты окружающей среды, состоянии экологического благополучия и нормативно-санитарном контроле.

Термины экологии воздуха варьируются также по **степени абстрактности**. Так, **конкретные номинации** типа *фильтр*, *смог*, *выхлопные газы*, *дым*, *аэрозоль* обозначают непосредственно воспринимаемые материальные объекты и явления. **Абстрактные термины**, такие как *экологическая ниша*, *экологическая безопасность*, *валентность среды*, обозначают концептуальные категории, отражающие системные свойства и параметры экосистем.

Особую группу составляют **обобщающие и уточняющие термины**. Например, слово *загрязнение* представляет собой обобщённое наименование негативного изменения качества среды. Уточняющие термины — *химическое загрязнение*, *световое загрязнение*, *антропогенное загрязнение*, *радиоактивное загрязнение* — конкретизируют характер воздействия, раскрывая причину, форму или источник загрязняющего действия. Такая терминологическая детализация способствует точности научного описания и формулирования нормативных документов в области охраны воздуха.

Заключение. Как отмечается, «современная экология характеризуется широким и системным межотраслевым взглядом, основанном на инкорпорации и концептуальном обобщении всех экологически ориентированных наук» [4, с. 45].

Проведённый анализ терминологической системы экологии воздуха позволил выявить закономерности её семантической и структурной организации, определить основные тематико-смысловые группы и проследить специфику их лингвистического оформления.

Таким образом, терминосистема экологии воздуха представляет собой многокомпонентную и структурированную лексико-семантическую систему, отражающую сложные взаимосвязи между природными, техногенными и правовыми аспектами охраны воздушной среды. Выделенные семантические группы терминов позволяют установить лексико-семантические связи по принципу «объект

— воздействие — реакция — регуляция», что способствует когнитивной упорядоченности и осмыслению экологических процессов.

Морфологический анализ показал, что в составе терминов преобладают многокомпонентные синтагмы, что свидетельствует о научной точности, системности и высоком уровне абстракции используемой лексики.

В лексике экологии воздуха прослеживается наличие эмоционально-оценочных компонентов, особенно в терминах, отражающих экологические риски, деградацию среды и антропогенное вмешательство.

В структуре терминов наблюдается баланс между заимствованной (интернациональной) и исконной лексикой, что отражает как глобализацию научной мысли, так и попытки адаптировать понятия к национальной языковой системе.

Список литературы

1. Ибрагимова К.К., Рахимов И.И., Зиятдинова А.И. Словарь-справочник терминов по экологии и охране природы: Учебное пособие. Казань, изд-во «Отечество», 2012.148 с.

2. Иванова Т. А. «Особенности формирования терминосистемы «Экология воздуха» в английском и русском языках: дис. … канд. филол. наук / Т. А. Иванова. — М., 2013. — 180 с.

3. Крючкова Н. Н. Лексико-семантические, словообразовательные и структурные особенности эко-терминов в русском и немецком языках: автореф. дис. ... канд. филол. наук: 10.02.19. — Краснодар, 2006. — 24 с.

4. Мананков А.В. Экология: учеб. пособие / А.В. Мананков. - Томск: Изд-во ТГАСУ, 2003. - 142 с.

5. Шадже А.Е., Сиротюк Э.А., Шадже А.И. Словарь терминов по экологии. – 2-е изд. доп. и перераб. – Майкоп: Изд-во ФГБОУ ВО «МГТУ», 2016. – 92 с.

PHILOSOPHICAL SCIENCES

ДИТЯЧІ ІГРИ В КОНТЕКСТІ ФІЛОСОФІЇ ПІЗНАННЯ

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CHILDREN'S GAMES IN THE CONTEXT OF THE PHILOSOPHY OF COGNITION

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Анотація

Актуальність теми дослідження обумовлена тим, що питання здобуття, обґрунтування, аналізу та використання знань не лише складають предмет філософії пізнання, а й формують світоглядні системи з фіксацією ролі і місця в них Людини. Перші кроки в пізнанні світу та формуванні світогляду людина (індивід) починає робити ще в дитинстві, зокрема – через різноманітні ігри. Мета дослідження – виявлення і аналіз пізнавального ресурсу дитячих ігор в онтологічному, соціокультурному та аксіологічному аспектах. Результати дослідження показали наявність трьох взаємопов'язаних режимів ігрового досвіду: тілесного, символічного і нормативного. Кожен із них відповідає окремому способу пізнання – через дію, через уявлення і через правило – і реалізуються у конкретних ігрових практиках: від рухливих ігор і формалізованих активностей з чітко заданими правилами до рольових сценаріїв та ігор-конструкторів. Це дає підстави говорити не лише про наявність у дитячих іграх пізнавального ресурсу, а й фіксувати його актуалізацію в різних аспектах: онтологічному, соціокультурному, аксіологічному. Поєднання всіх цих аспектів в досвіді індивіда сприяє формуванню у нього певного світогляду, світорозуміння.

Abstract

The relevance of the research topic is due to the fact that the issues of acquiring, substantiating, analyzing, and using knowledge not only constitute the subject of the philosophy of knowledge, but also form worldview systems with the fixation of the role and place of Man in them. A person (individual) begins to take the first steps in understanding the world and forming a worldview in childhood, in particular through various games. The purpose of the study is to identify and analyze the cognitive resource of children's games in ontological, sociocultural, and axiological aspects. The results of the study showed the presence of three interconnected modes of game experience: bodily, symbolic and normative. Each of them corresponds to a separate way of cognition – through action, through representation and through a rule – and are implemented in specific game practices: from outdoor games and formalized activities with clearly defined rules to role-playing scenarios and construction games. This gives grounds to speak not only about the presence of a cognitive resource in children's games, but also to record its actualization in various aspects: ontological, socio-cultural, axiological. The combination of all these aspects in the experience of an individual contributes to the formation of a certain worldview.

Ключові слова: знання, епістемологія, світогляд, культура, людина, соціум, моделювання, символізація, цінності, творчість.

Keywords: knowledge, epistemology, worldview, culture, man, society, modeling, symbolization, values, creativity.

Вступ. Питання здобуття, обґрунтування, аналізу та використання знань не лише складають предмет філософії пізнання, а й формують світоглядні системи з фіксацією ролі і місця в них Людини.

Перші кроки в пізнанні світу та формуванні світогляду людина (індивід) починає робити ще в дитинстві, зокрема – через різноманітні ігри.

Тому в гуманітарних і педагогічних дослідженнях гра дедалі частіше розглядається не лише

як форма дозвілля чи дитячої активності, а як складний феномен, що має потужний пізнавальний потенціал. Попри поширене уявлення про гру як «несерйозну» діяльність, вона виявляється одним із базових способів освоєння світу, через який суб'єкт набуває досвіду, формує моделі поведінки та засвоює культурні норми. Водночас питання про те, у чому саме полягає пізнавальний ресурс гри, потребує уточнення. Різні ігрові практики, зокрема у дитячому середовищі, реалізують різні механізми взаємодії з реальністю – від тілесного набуття навичок та розвитку моторики до символічного моделювання соціальної реальності та конструювання складних систем. Це дозволяє розглядати гру як багаторівневий механізм організації досвіду з пізнання світу та ролі людини в ньому.

Аналіз останніх досліджень і публікацій. Проблеми теорії пізнання посідають важливе місце у філософських дослідженнях, адже вивчення процесу здобуття, обґрунтування та функціонування знань є одним із завдань філософії. Проблематика пізнання висвітлюється в працях Дж. Локка, Ф. Бекона, Дж. Берклі, Г. Лейбніца, Д. Юма, І. Канта, Г.В.Ф. Гегеля, Г. Когена, Е. Касирера, Л. Вітгенштейна, Г.Г. Гадамера, Е. Гусерля, М. Гайдеггера та багатьох інших філософів, які пропонували різні підходи до осмислення процесу і результатів пізнання.

Проте не лише філософія, а й спеціальні науки розглядають пізнавальний процес під різними кутами зору.

Експериментальна психологія В. Вундта, наприклад, сприяла формуванню когнітивної науки і когнітивної лінгвістики [1].

На перехресті філософії і соціології формується думка про те, що в інформаційному суспільстві знання постають як соціальний феномен, що дає підстави розглядати науку як складно організовану колективну практику, як єдиний соціальний проєкт, в якому система знань постає як фрактальна конструкція, організація якої змінюється внаслідок саморозвитку колективного суб'єкта пізнання [2].

Культурологія та філософія культури розглядають теорію пізнання крізь призму поняття «символ», спираючись на твердження про те, що символізація відіграє головну роль у мисленні [3]. Цей підхід притаманний і філософським концепціям, в яких одним із проявів символізації розглядається метафора, але не просто як спосіб формування образів, а ще й як потужний гносеологічний інструмент [4; 5].

Специфічний міждисциплінарний дискурс формується навколо дослідження гри як соціокультурного феномену [6; 7; 8]. Якщо цей феномен досліджувати на предмет виявлення його пізнавально-онтологічного потенціалу, то дискурсивне поле суттєво розширюється через поєднання предметів, методів і підходів культурології, педагогіки, когнітивістики, соціальної філософії, аксіології та філософії пізнання.

Мета дослідження – виявлення і аналіз пізнавального ресурсу дитячих ігор в онтологічному, соціокультурному та аксіологічному аспектах.

Методи дослідження. Основними методами даного дослідження є методи аналізу та синтезу (для узагальнення теоретичного матеріалу), структурно-функціональний аналіз (при виявленні функцій окремих ігор в структурах ігрових практик), феноменологічний метод (для розгляду гри як процесу і результату пізнавальної діяльності людини при формуванні певного світосприйняття, світогляду).

Результати дослідження. Однією з перших системних інтерпретацій гри в науковому дискурсі є підхід, представлений у працях Карла Гросса [9; 10], який розглядав гру як форму підготовки до майбутньої життєвої діяльності. Гра постає передусім як механізм тренування, спрямований на розвиток базових функцій організму та засвоєння ефективних способів взаємодії з довкіллям. У дитячій поведінці це проявляється у тілесно-практичних іграх, пов'язаних із відпрацюванням рухів, координації та маніпуляції з об'єктами. Такі дії мають повторюваний характер і орієнтовані на досягнення точності, ритмічності та контролю. Гра виконує функцію сенсомоторного навчання: дитина водночас опановує й осмислює світ через тілесний досвід. Відповідно, пізнавальний ресурс гри тут реалізується як формування практичних умінь і навичок, що забезпечують: орієнтацію в просторі, узгодження рухів, ефективну взаємодію з предметним середовищем, тощо.

Та навіть на цьому «базовому» рівні гра не зводиться до суто фізичного тренування. Вже в тілесно-практичних іграх формується первинний соціальний досвід, пов'язаний із взаємодією з іншими. Це особливо виразно проявляється у командних іграх, таких як футбол, баскетбол, естафети, де тілесна активність поєднується зі спільною організацією дії. Граючи в них, дитина не лише вчиться вправно керувати своїм тілом, але й засвоює принципи роботи у команді: координацію між учасниками, розподіл ролей, взаємну залежність результату. У процесі гри виникає досвід відповідальності перед іншими, необхідність узгодження власних дій із діями команди, уміння працювати в умовах суперництва, повага до опонента.

Водночас пояснення гри виключно через її тренувальну функцію виявляється недостатнім для опису всього спектра ігрових практик. Тілесно-практичні ігри, попри їхню важливість, охоплюють лише той рівень взаємодії зі світом, який пов'язаний із безпосередньою дією та сенсомоторним досвідом. У цьому контексті показовою є класифікація Жана Піаже, який розрізняє ігри-вправи, символічну гру та ігри з правилами [11]. Перший тип безпосередньо відповідає описаним тілесно-практичним формам.

Однак існують такі види ігрової діяльності, які не можуть бути зведені до тренування або підготовки до майбутніх дій. Зокрема, у символічній грі дитина взаємодіє не з безпосередньою реальністю, а з її уявними моделями: предмети використовуються як замінники (листя рослин стають грошима, а звичайна дерев'яна палиця – списом, чарівним посохом, жезлом дорожнього патруля, тощо), а дії набувають умовного характеру. Тобто, у символічній

грі принципово інший тип взаємодії з реальністю: дитина не адаптується до вже заданих умов, а оперує значеннями, відокремленими від безпосереднього досвіду. Це дозволяє «приміряти» на себе іншу роль та випробовувати альтернативні моделі поведінки. Як зауважує Р.М. Поліщук, «жодних фіксованих або жорстких правил не існує для гри в ляльки, для гри в солдатиків, поліцейських і розбійників, коней, локомотивів і літаків, взагалі ігор, які передбачають вільну імпровізацію і головна привабливість яких полягає в задоволенні зіграти роль, діяти так, ніби ви були кимось або чимось іншим, наприклад, машиною» [6, с. 70].

Разом з тим, в іграх такого типу дитина відтворює структури соціальної взаємодії, розподіл ролей і нормативні очікування. Хоча на перший погляд може здатися, що в такому типі ігор відсутній чітко окреслений набір правил, відігрування повинно проходити в прийнятних межах. Порушення таких імпліцитних правил одразу фіксується учасниками: якщо, наприклад, у грі в лікаря «лікар» замість лікування починає завдавати шкоди «пацієнту», така поведінка оцінюється як «неправильна» і виводиться за межі гри.

Потенціал соціального моделювання є характерним для дитячих ігор з ляльками, за допомогою яких діти «програють» різні сценарії поведінкових та комунікативних моделей і, водночас, формують систему цінностей, адже «лялька не лише є зменшеною копією людини, в ній моделюється весь комплекс людських відносин і культурних цінностей, які формують сутність соціальної реальності» [12]. Не менш потужним способом ігрового моделювання соціальної реальності є участь дітей у театральних виставах, коли діти можуть «приміряти» на себе різні соціальні ролі в різних ситуаціях. В педагогічній практиці це сприяє вихованню дітей, формуванню їх світоглядних позицій, морально-етичних цінностей, естетичних ідеалів, засвоєнню правил поведінки, задоволенню творчих потреб, тощо [13; 14].

Поряд із символічною грою, де правила мають імпліцитний і гнучкий характер та формуються у процесі взаємодії, існують ігри з правилами, у яких нормативна система є явно визначеною, стабільною і попередньо заданою. У цьому випадку учасник гри вже не створює умови взаємодії ситуативно, а входить у наперед задану структуру, яку необхідно прийняти як обов'язкову. Правила можуть змінюватися протягом ігрової сесії за домовленістю учасників (або одного учасника, якщо він тренується або грає сам з собою), але сам ігровий процес призупиняється під час їх обговорення.

Характерним прикладом гри з заданою структурою правил є шахи [15], де кожен елемент гри має чітко визначені функції, а допустимі дії суворо регламентовані. Ігрова ситуація тут не конструюється довільно, як у символічних іграх, а розгортається в межах фіксованої системи можливостей. Це вимагає від учасника здатності до планування, передбачення та побудови послідовних стратегій, що переводить гру на рівень абстрактного мислення.

Принципова особливість ігор з заданою системою правил полягає в тому, що правила виступають умовою можливості самої гри. На відміну від рольових ігор, де порушення неявних норм може бути переосмислене або інтегроване в процес, тут відхилення від правил підриває саму структуру взаємодії. Це означає, що учасник змушений співвідносити власні дії з загальною системою, яка однаково обов'язкова для всіх. Через це формується специфічне ставлення до норм як до інструменту організації спільної діяльності. Дитина засвоює, що правила не є зовнішнім обмеженням, а умовою, що забезпечує передбачуваність і можливість координації з іншими. У цьому контексті виникає розуміння справедливості як рівності умов, відповідальності за дотримання правил і визнання іншого як рівноправного учасника гри.

Водночас існують ігрові практики, які поєднують у собі елементи правил і конструювання, переводячи діяльність на рівень роботи з системами. Таких можливостей надають, наприклад, ігри-конструктори, які є особливо важливими на перших етапах розвитку дитини, коли вона не лише пізнає світ, а й робить перші спроби з його творчого перетворення. Використання конструкторів, зокрема LEGO, в ігровій діяльності «дозволяє дітям старшого дошкільного віку не тільки втілювати свої ідеї в матеріальні форми, але й сприяє розвитку навичок співпраці, вирішення проблем і експериментування» [16]. Ще більш широкого простору для експериментування-конструювання у форматі гри надають заняття у гуртках початково-технічного спрямування в рамках STEM-освіти. Тут діти через створення різних моделей (з різних матеріалів, за різними технологіями) залучаються до пізнання і розуміння світу техніки крізь призму технічної творчості, через досвід власної творчої діяльності, опанування системи початкових технічних та технологічних знань, умінь і навичок. Така діяльність стимулює допитливість, підтримує інтерес до навчання та пошуку знань, мотивує до самостійних досліджень [17].

У сучасних умовах ця логіка поширюється і на цифрові ігрові середовища, зокрема Terraria, Starbound, Factorio, Roblox та Minecraft. У Minecraft, окрім можливості вільного конструювання об'єктів, гравець може відтворювати складні технічні системи. Завдяки механіці «редстоуну» гравець може створювати логічні схеми, що працюють на принципах двійкової логіки: сигнали можуть перебувати у станах «увімкнено» або «вимкнено», що відповідає значенням 1 і 0. На цій основі можливо побудувати базові логічні елементи (кон'юнктори, диз'юнктори, інвертори), а також складніші системи – від суматорів і триггерів до повноцінних обчислювальних пристроїв, включаючи комп'ютери. Таким чином, ігри з правилами та конструктивні ігрові практики відкривають ще один вимір пізнання – взаємодію з системами, що поєднує логічне мислення, планування, розуміння структурних зв'язків з творчістю та розвитком уяви.

Висновки. Узагальнюючи результати дослідження, можна говорити про три взаємопов'язані режими ігрового досвіду, які можуть комбінуватися один з одним: тілесний,

символічний і нормативний. Кожен із них відповідає окремому способу пізнання – через дію, через уявлення і через правило – і реалізуються у конкретних ігрових практиках: від рухливих ігор і формалізованих активностей з чітко заданими правилами до рольових сценаріїв та ігор-конструкторів.

Водночас у кожному з цих режимів формуються не лише знання, але й система цінностей. У тілесно-практичних іграх дитина засвоює межі власного тіла, розвиває самоконтроль і вчиться взаємодіяти з іншими у спільному просторі. У символічних іграх відбувається освоєння соціальних ролей, норм і моделей поведінки, що супроводжується формуванням уявлень про допустиме, належне і бажане. Конструктивні ігри формують здатність до творчого перетворення середовища, а також навички планування і вирішення проблем. Ігри з правилами, у свою чергу, вводять дитину у сферу нормативних структур, де вона стикається з принципами справедливості, рівності умов та визнання іншого як рівноправного учасника взаємодії.

Все це дає підстави говорити не лише про наявність у дитячих іграх пізнавального ресурсу, а й фіксувати його актуалізацію в різних аспектах: онтологічному, соціокультурному, аксіологічному. Поєднання всіх цих аспектів в досвіді індивіда сприяє формуванню у нього певного світогляду, світорозуміння.

Список літератури

1. Мельничук, О.Д. Теорія пізнання як основа когнітивної науки: філософський та лінгвістичний аспекти. *Закарпатські філологічні студії*, 2019, Вип. 10, Том 2, С. 10-14. DOI: 10.32782/tps2663-4880/2019.10-2.2.

2. Плющ, О. Методологія пізнання у постінформаційних суспільствах. *Вчені записки Університету «Крок»*, 2023, № 1(69). С. 188-196. DOI: 10.31732/2663-2209-2022-69-188-196.

3. Шумка, М., Гнасевич, Н., Сілаєва, Т. Еволюція символічної теорії пізнання у західноєвропейській філософській думці. *Наукові записки ТНПУ ім. В. Гнатюка, Серія «Філософія»*, 2005, Вип. 13. С. 113-120.

4. Lakoff, G., Johnson, M. Metaphors We Live Be. Chicago; London: University Press, 1980. 242 p.

5. Шніцер, М.М. Метафора у філософії та філософія у метафорі. *Гілея: науковий вісник*, 2017, Вип. 127. С. 200-205.

6. Поліщук, Р.М. Гра як творче начало культури: Й. Гейзинга та Р. Кайуа. *Актуальні проблеми філософії та соціології*, 2024, № 47. С. 136-143. DOI: 10.32782/apfs.v047.2024.12.

7. Чумаченко, О.А. Осмислення феномену гри в сучасній культурологічній думці. *Філософія подієвої культури: історія та сучасність*: матеріали Всеукраїнської науково-практичної конференції (Київ, Україна, 25-26 березня 2021 р.). Київ, 2021. С. 192-195.

8. Лаврова, І.І., Сараєва, О.В. Вивчення історії культури через ігрові технології. *Вісник науки та освіти*, 2023, № 4(10). С. 530-538. DOI: 10.52058/2786-6165-2023-4(10)-530-538.

9. Groos, K. The Play of Animals / translated by Elizabeth L. Baldwin. New York: Appleton, 1898.

10. Groos, K. The Play of Man / translated by Elizabeth L. Baldwin. New York: Appleton, 1901.

11. Piaget, Jean. Play, Dreams and Imitation in Childhood. London: Routledge, 1951, p. 110.

12. Прокопович, Л.В. Соціально-філософські аспекти культурних функцій ляльок у «театрі» буття. *Гілея: науковий вісник*, 2019, Вип. 140(1), Ч. 2. Філософські науки. С. 83–88.

13. Прокопович, Л.В. Навчальні, виховні та психотерапевтичні практики з елементами театральної гри: соціально-філософський аспект. *Вісник Львівського університету. Серія філософсько-політологічні студії*, 2019, Вип. 25. С. 57–63. DOI: 10.30970/2307-16164.2019.25.8.

14. Возна, Ю.В. Анімація у сценічній роботі соціального педагога. *Актуальні дослідження в соціальній сфері*: матеріали десятої міжнародної наук.-практ. конф. (Одеса, 17 листопада 2017 р.). Одеса, 2017. С. 161–164.

15. Прокопович, Л.В. Шахи як джерело метафор для соціально-філософських рефлексій. *The scientific heritage*, 2026, № 177. С. 89-91. DOI: 10.5281/zenodo.18451500.

16. Клевака, Л.П., Гресь, К.О. Формування креативності у дітей старшого дошкільного віку в ігровій діяльності з використанням конструктора LEGO. *Суспільство та національні інтереси*, 2025, № 1(9). С. 65-74. DOI: 10.52058/3041-1572-2025-1(9)-65-74.

17. Скіпор, І., Нечипоренко, О. Початкове технічне моделювання – основа формування технічних знань молодших школярів. *STEM-освіта: теорія і практика*: Збірник науково-методичних матеріалів. Київ: Освіта, 2024. С. 337-346.

PHYSICS AND MATHEMATICS

NON-DESTRUCTIVE ABSORPTION OF A SMALL COUNTER-ROTATING VORTEX BY A SPHERICAL HILL VORTEX

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Abstract

Within the framework of an ideal incompressible fluid, the problem of absorption of a small counter-rotating vortex by a spherical Hill vortex in a non-destructive regime ($\varepsilon \ll 1$) is considered. Unlike the work of Moffatt and Moore [2], which investigated axisymmetric perturbations of the same sign, the present study addresses the physically significant case of capturing a counter-rotating vortex. A Gaussian model of a localized vortical perturbation is constructed; closed-form expressions are obtained for the velocity field, the vorticity perturbation $\delta\omega_\varphi$ and the asymmetry of the pressure field after the interaction. An absorption criterion is formulated in terms of the stream function. It is shown that the captured vortex does not persist as an independent structure but is redistributed along closed streamlines. Analytical expressions are derived and compared with numerical results for the changes in circulation Γ, hydrodynamic impulse I, propagation velocity U, angular momentum L_z and moment of inertia $\mathcal{J}_z$. It is established that: (i) the spherical shape of the Hill vortex is preserved up to order $\mathcal{O}(\varepsilon)$; (ii) a localized vortical core forms in the outer layers as a result of the interaction; (iii) the propagation velocity decreases by an amount proportional to I_s/I_H; (iv) passive scalar transport is reorganized along the potential layers of the modified vortex.

Keywords: Hill vortex, vortex absorption, vorticity, stream function, vortex interaction, circulation, hydrodynamic impulse, angular momentum, axisymmetric flow, passive scalar transport, formation of a vortical core

1. Introduction. The spherical Hill vortex [1] is one of the few exact three-dimensional solutions of the Euler equations for an incompressible inviscid fluid. It propagates rectilinearly with velocity U in a quiescent medium while remaining topologically closed: all fluid inside the sphere $r^2 + z^2 < a^2$ moves along closed toroidal streamlines, whereas the external flow is potential. The combination of compactness and exact analytical structure makes this vortex a canonical object for studying transport in vortical flows [2–9].

The linear stability of the Hill vortex to small axisymmetric perturbations was studied by Moffatt and Moore [2], who showed that such perturbations preserve the vortex topology. Vortex rings—closely related structures—were examined in detail by Meleshko et al. [3], and their stretching and folding dynamics form the basis of fast dynamo theory [4, 5]. However, the question of what occurs during the capture of a counter-rotating vortex with opposite-signed impulse has not yet received a direct analytical treatment.

This scenario is physically relevant in several contexts: (a) the interaction of coherent vortical structures in turbulent flows, where vortices of opposite sign arise as a result of reconnection; (b) the capture of background vorticity by large-scale vortices; (c) magneto-hydrodynamic (MHD) dynamo models in conducting media [6], where the background vortical field modulates a translating spherical vortex. The present work fills this gap by constructing an explicit perturbation model for the absorption process and deriving closed-form analytical expressions for all integral characteristics of the Hill vortex after absorbing a small counter-rotating vortex.

Unlike [2], where axisymmetric perturbations of the same sign were considered, the present work: (i) introduces a counter-rotating Gaussian vortex as an admixture; (ii) derives the full set of post-absorption invariants - including the angular momentum L_z, which is identically zero in the classical Hill vortex - in closed form; (iii) proves that, as a result of the interaction of the outer layers, a localized vortical core emerges ($\delta\omega_\varphi \neq Ar$) - an effect absent in all previous analytical studies; (iv) shows that passive scalar transport is reorganized along the closed potential layers of the perturbed vortex, with the impurity cloud retaining a spiral structure over timescales$\tau \sim a/U$.

2. Governing Equations of the Base Hill Vortex. We work in cylindrical coordinates $(r, \theta, z), r = \sqrt{x^2 + y^2}$. The Hill vortex is an axisymmetric solution of the Euler equations without azimuthal velocity ($u_\theta = 0$). The stream function inside the sphere has the form:

$$\psi_H = Ar^2(a^2 - r^2 - z^2)/10 \quad (1)$$

where $A = 15u/2a^2$ (2)

The vorticity region is bounded by the sphere

$$r^2 + z^2 < a^2. \quad (3)$$

The only nonzero component of vorticity is the azimuthal one:

$$\omega_\varphi^{(H)} = Ar = 15Ur/(2a^2)\,, \quad (4)$$

This *linear* profile - where the vorticity increases monotonically from zero on the axis to a maximum at the equator - fundamentally distinguishes the Hill

vortex from Rankine or Lamb - Oseen vortices, which possess a compact, highly vortical core. The Hill vortex does not have a core in the classical sense: the vorticity fills the entire sphere uniformly (Fig. 1). Outside the sphere, the flow is potential:

$$\Psi_H = (Ur^2/2)\left(1 - \left(a^3/(r^2+z^2)^{3/2}\right)\right) \quad (5)$$

Velocity components inside the sphere:

$$u_r^{(H)} = 3Urz/2a^2\,, \quad (6)$$

$$u_z^{(H)} = (3U/2)(1 - ((2r^2+z^2)/a^2)$$

Hydrodynamic impulse, which determines the propagation velocity (Section 4):

$$I_H = 2\pi\rho U a^3\,,\ U = I_H/(2\pi\rho a^3) \quad (7)$$

3. Model of the captured small vortex. The incoming small vortex has radius $b = a/2$ and moves toward the Hill vortex. Its influence is introduced as a localized perturbation of the stream function:

$$\delta\psi(r,z,t) = \varepsilon U a r^2 \exp(-q/2\sigma^2)\exp(-t/\tau) \quad (8)$$

where $\varepsilon \ll 1$ is the perturbation amplitude, σ is the characteristic scale of the capture region, $\tau \sim a/U$ is the absorption timescale, and $q = (r-r_c)^2 + (z-z_c)^2$ is the squared distance from the vortex center (r_c, z_c). The exponential temporal decay describes the redistribution of the captured vortex along closed streamlines. The corresponding velocity perturbations are:

$$\delta u_r = (\varepsilon U a r(z-z_c)/\sigma^2)\exp(-q/2\sigma^2)\,, \quad (9)$$

$$\delta u_z = \varepsilon U a[2 - (r(r-r_c)/\sigma^2)]\exp(-q/2\sigma^2). \quad (10)$$

The total velocity field $u = u^{(H)} + \delta u$ satisfies the solenoidal condition $\nabla \cdot \mathbf{u} = 0$, since $\delta\psi$ is a properly defined stream function. *Absorption criterion* (the vortex center must lie on a closed streamline):

$$r_c^2 + z_c^2 < a^2 \text{ и } \psi_H(r_c, z_c) > 0 \quad (11)$$

The first condition is geometric (the center must lie inside the sphere), while the second ensures that the center lies on a *closed* streamline of ψ_H. If $\psi_H \le 0$, the impurity will leave the vortex through the equatorial region. The non-destructive regime is ensured by the conditions $\varepsilon \ll 1$ and $\max|\delta\mathbf{u}| \ll U$.

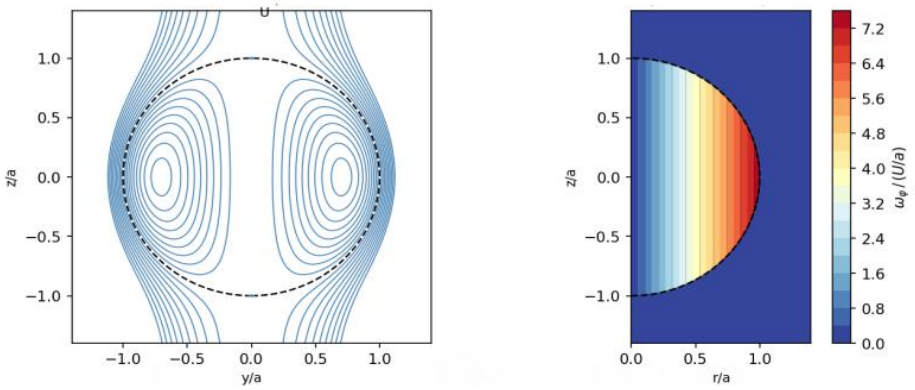

Fig. 1. Left: streamlines of the spherical Hill vortex in the (y,z) plane (dashed circle: boundary of the sphere $r^2+z^2=a^2$; arrow: direction of U). Right: azimuthal vorticity $\omega_\varphi/(U/a)$ inside the sphere, confirming the linear profile $\omega_\varphi = Ar$.

4. Propagation Velocity After Absorption. We use the hydrodynamic impulse to analyze the change in propagation velocity. For an axisymmetric vortex with vorticity ω_φ :

$$I = \pi\rho \iint_D \omega_\varphi r^2 dr dz\,. \quad (12)$$

For the Hill vortex, this yields:

$$I_H = \pi\rho A \iint_D r^3 dr dz = 2\pi\rho U a^3, \quad (13)$$

from which it follows that

$$U = I_H/2\pi\rho a^3 \quad (14)$$

After the absorption of a small vortex with its own impulse $I_s < 0$ (moving oppositely), into a new Hill-type structure with radius $a_+ \approx a$:

$$U_+ = (I_H + I_s)/(2\pi\rho a_+^3) \quad (15)$$

In physical terms, the deceleration of the vortex is explained by the fact that the counter-rotating vortex carries negative axial impulse, partially compensating the impulse of the Hill vortex. This represents a hydrodynamic analogue of momentum conservation. In the weak absorption regime, $|I_s| \ll I_H$ (т.е. $\varepsilon \ll 1$):

$$(U_+ - U)/U \approx I_s/I_H \sim \mathcal{O}(\varepsilon)\,. \quad (16)$$

This confirms the non-destructive nature of the absorption: the vortex structure is preserved at leading order, while the change in velocity constitutes a small first-order correction in ε.

5. Change in Azimuthal Vorticity and Core Formation. The vorticity perturbation induced by the captured vortex is calculated as

$\delta\omega_\varphi = (\partial\delta u_r/\partial z) - (\partial\delta u_z/\partial r)$ that we have:

$$\delta\omega_\varphi(r,z) = -(\varepsilon U a/\sigma^4)[r(q-5\sigma^2) + 3r_c\sigma^2]\exp(-q/2\sigma^2)\,. \quad (17)$$

The vorticity profile after absorption is given by:

$$\omega_\varphi^+ = Ar + \delta\omega_\varphi.$$

The key physical point is that $\delta\omega_\varphi$ *is not proportional to* r: the Gaussian factor introduces a localized deviation from the classical linear profile in the vicinity of (r_c, z_c). This corresponds to the emergence of a **local vortical core** - a region of enhanced vorticity that breaks the coreless nature of the original Hill vortex. The core width is ~ σ, and its peak amplitude is $\sim \varepsilon U a/\sigma^2 \gg Ar_c$ for $\sigma \ll r_c$. This mechanism - core formation through the interaction of outer layers - has no analogue in the theory of axisymmetric perturbations [10].

6. Circulation. The meridional circulation of the Hill vortex is described via the cross-section D:

$$\Gamma_H = \iint_D \omega_\varphi^{(H)} dr dz = A \iint_D r\, dr dz = 2Aa^3/3 = 5Ua \quad (18)$$

After absorption, the *meridional circulation* of the Hill vortex through the cross-section D is given by:

$$\Gamma_+ = \Gamma_H + \delta\Gamma\,, \delta\Gamma = \iint_D \delta\omega_\varphi dr dz\,. \quad (19)$$

Sign of $\delta\Gamma$. For a counter-rotating captured vortex, the perturbation $\delta\omega_\varphi$ is, on average, negative over the domain D (the negative contribution in equation (16) dominates for $q \gg 5\sigma^2$), therefore, $\delta\Gamma < 0$ and the total circulation decreases. For a co-rotating vortex $\delta\Gamma > 0$. The magnitude $|\,\delta\Gamma\,| \sim \varepsilon U a \sigma = \mathcal{O}(\varepsilon)$ relative to $\Gamma_H = 5Ua$, which is consistent with the assumption of a non-destructive regime.

7. Mass, Volume, and Density. The Hill vortex is not a rigid body; one can speak only of the mass contained within the vortical region. For an incompressible fluid of constant density ρ and an almost unchanged radius, $a_+ \approx a$:

$$V_H = 4\pi a^3/3\,, M_H = \rho V_H, \rho_+ = \rho\,. \quad (20)$$

The density remains unchanged - only the velocity field, pressure field, and vorticity distribution are modified. If the absorption is accompanied by a small expansion $\delta a \sim \mathcal{O}(\varepsilon a)$, the volume changes as $a_+^3 = a^3\big(1 + \mathcal{O}(\varepsilon)\big)$ so the correction is negligibly small at first order in ε (see Figs. 2 and 3).

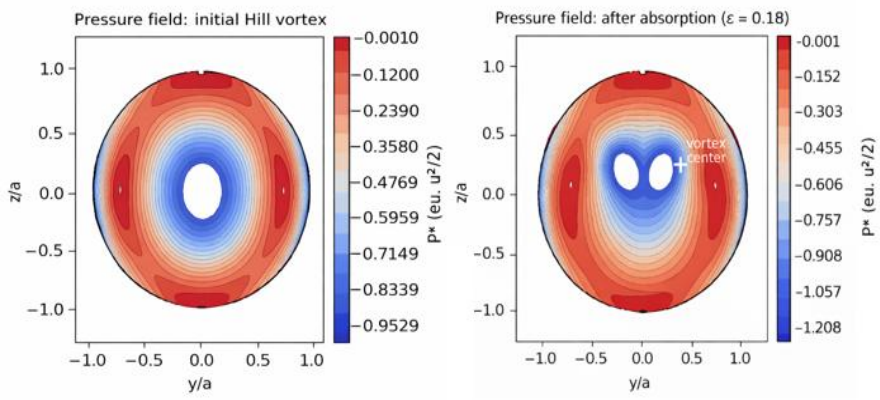

Fig. 2. Pressure isocontours $P^* = -u^2/2$ in the (y, z) plane $(a = 1, U = 1, \varepsilon = 0.18)$. Left: the initial spherical Hill vortex (symmetric pattern). Right: after the capture of a counter-rotating vortex at $(r_c, z_c) = (0.35, 0.25)$ with $\sigma = 0.22$. The white cross marks the center of the captured vortex. The breakdown of pressure symmetry is a direct consequence of $\delta\omega_\varphi \neq 0$.

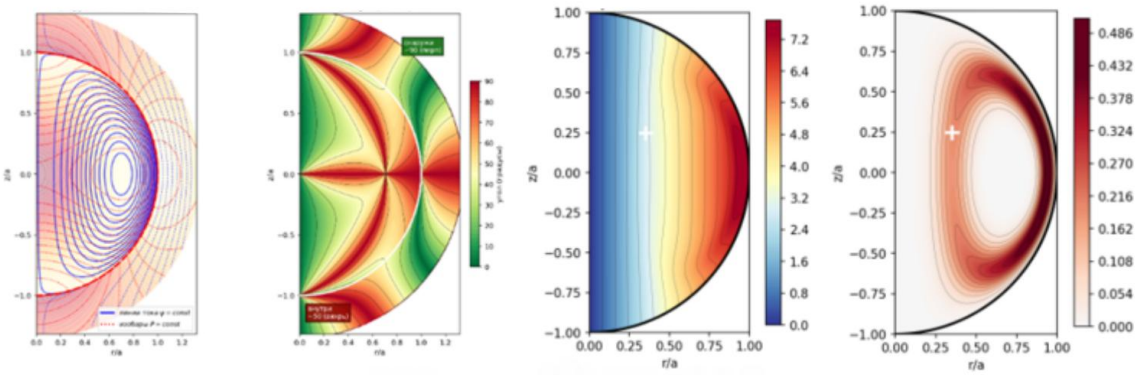

Fig. 3. (a) - (b): streamlines and isobars; the angle between them; (a) Streamlines (blue) and isobars (red); the angle between an isobar and a streamline: 0^0 - parallel, 90^0 - perpendicular. From panel (b), it is evident that inside the vortex the angle is 90^0, indicating orthogonality of the lines. Within the vortex, the angle $\beta \neq 0$ (the velocity is non-uniform along the torus); (c) Distribution of vorticity after absorption $\omega^+ = F(\psi) \cdot r$ (with a "hump"); (d) Distribution of the "impurity" vorticity according to the generalized formula $\delta\omega = (F(\psi) - A) \cdot r$. The deformation of streamlines after absorption is clearly visible; in the equatorial region near the vortex boundary, a noticeable concentration of vorticity is observed.

8. Angular Momentum Before and After Absorption. The classical Hill vortex has no azimuthal velocity $(u_\theta^{(H)} = 0)$, and therefore its angular momentum with respect to the axis of symmetry is zero:

$$L_z^{(H)} = \rho \iiint_V r u_\theta dV = 0,. \quad (21)$$

After the absorption of a small vortex with transverse swirl of amplitude ε_θ, a nonzero azimuthal velocity appears inside the sphere:

$$u_\theta^{(\mu)}(r, z) = \varepsilon_\theta u \frac{r}{\sigma_\theta} \exp(q/2\sigma_\theta^2)\,, (22)$$

and the angular momentum after absorption is given by:

$$L_z^{(+)} = 2\pi\rho \iint_D r^2 u_\theta^{(\mu)}(r, z) dr dz \approx$$
$$\approx 4\pi^2 \rho \varepsilon_\theta u (r_c^3 + 3r_c\sigma_\theta^2)\sigma_\theta\,. \quad (23)$$

Physical mechanism. The emergence of $L_z > 0$ signifies a qualitative change in the nature of the vortex: the Hill vortex transitions from a purely translational coherent structure to one possessing a weak intrinsic rotation. This is analogous to the Magnus effect: a body with transverse rotation undergoing translational motion experiences a lateral force - here, instead,

internal rotation of the fluid is generated. Since $L_z^{(+)} = 0$, the entire angular momentum after absorption is due to the captured vortex:: $\Delta L_z = L_z^{(+)}$.

9. Moment of Inertia and Effective Angular Velocity. Treating the vortical region as a homogeneous sphere of density ρ and radius a, the moment of inertia with respect to the axis of symmetry is given by

$$\mathcal{J}_z = \iiint_V \rho\, r^2\, dV = 2M_H a^2/5 = 8\pi\rho a^5/15\,. \quad (24)$$

the moment of inertia does not change at leading order. The effective angular velocity characterizing the weak internal rotation is given by:

$$\Omega_{eff} = L_z/\mathcal{J}_z \Rightarrow \Omega_{eff}^{(+)} = 15L_z^{(+)}/8\pi\rho a^5. \quad (25)$$

Before absorption $\Omega_{eff} = 0$ (no intrinsic rotation). After absorption, $\Omega_{eff}^{(+)} \sim \varepsilon_\theta U/a$ which is small but nonzero. This rotation is not rigid-body in nature; rather, it reflects the net circulation of the fluid around the axis of symmetry within the vortex volume. The ratio $\Omega_{eff}^{(+)} a/U \sim \varepsilon_\theta$ confirms the non-destructive character of the process.

10. Transport and Redistribution of a Passive Scalar. The concentration of a passive impurity $C(\mathrm{x}, t)$, associated with the captured vortex, evolves according to the advection equation:

$$\partial \mathrm{C}/\partial \mathrm{t} + \mathbf{u} \cdot \nabla C = 0,$$
$$C(\mathrm{x}, 0) = C_0 \exp(-q2\sigma^2). \quad (26)$$

Why does the scalar redistribute along streamlines? In an ideal fluid, ψ = const along particle trajectories, i.e. ψ is a Lagrangian invariant. Therefore, any impurity initially localized near (r_c, z_c) will be advected along the closed torus $\psi = \psi_H(r_c, z_c)$, spreading over it but not leaving this layer. After several revolutions, the impurity uniformly fills the torus (due to kinematic mixing; the flow becomes weakly non-integrable after absorption). The resulting distribution is **layered and step-like**: each closed streamline carries an almost constant concentration, while sharp gradients arise between layers. This constitutes **the mechanism of passive scalar redistribution**: in the absence of diffusion (Euler equations), there is no radial transport across streamlines, but reorganization occurs within each potential layer.

Integral measure of absorption completeness:

$$\eta(t) = \frac{1}{M_0} \iiint_{r^2+z^2<a^2} \mathrm{C}(\mathbf{x}, \mathrm{t})\, dV \text{ at } t \to \infty \quad (27)$$

The absorption time $\tau_{abs} \sim \tau$ is determined by the turnover time of the fluid within the Hill vortex. For the parameters used in the figures ($\sigma = 0.22a, \varepsilon = 0.18$), the impurity is effectively absorbed ($\eta < 0.05$) by the time $t \sim 4a/U$, which is consistent with Fig. 4.

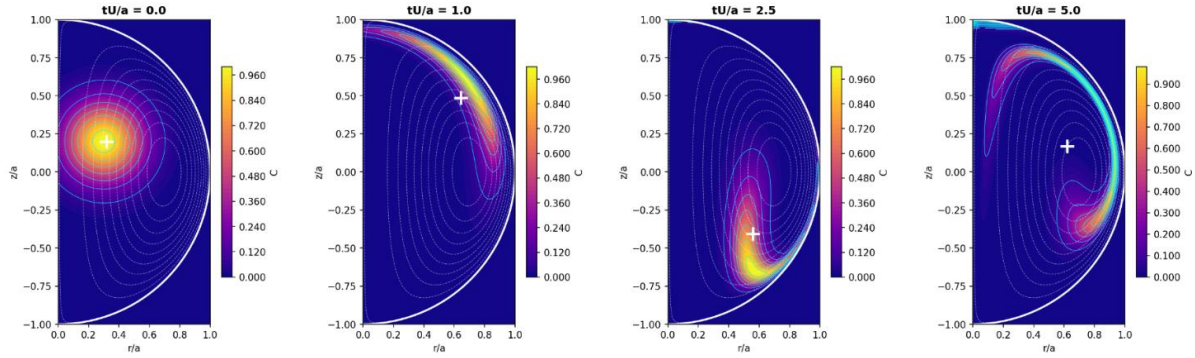

Fig. 4. Passive scalar transport in the Hill vortex after absorption. The impurity concentration $C(r, z, t)$ is shown at four time instants ($\varepsilon = 0.18, \sigma = 0.22a, r_c = 0.30a, z_c = 0.20a$). The initially localized cloud redistributes along closed toroidal streamlines, gradually filling the corresponding potential layer while retaining a spiral structure characteristic of the streamline topology.

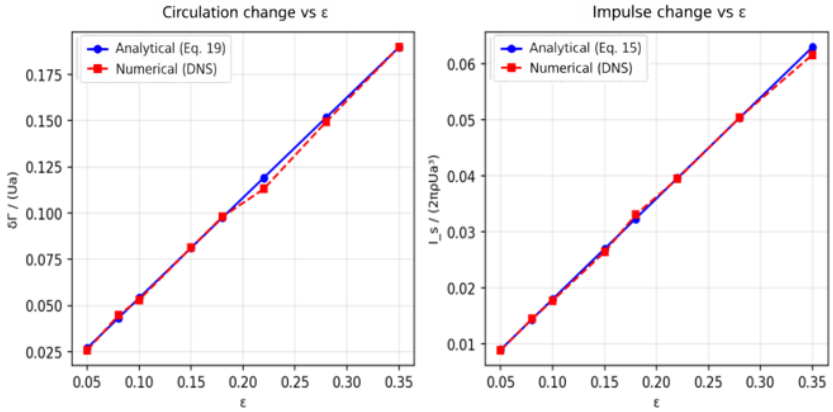

Fig. 5. Comparison of analytical predictions (solid blue) with numerical results (red dashed) for the change in circulation $\delta\Gamma/(\mathrm{Ua})$ (left) and impulse $I_s/(2\pi\rho U a^3)$ (right) as functions of ε. Parameters: $r_c = 0.35a, z_c = 0.25a, \sigma = 0.22a$. The agreement is better than 1-2% for $\varepsilon < 0.25$, confirming the applicability of the first-order analytical model in the non-destructive regime.

11. Numerical Verification. To validate the analytical model, we compare the predicted changes in circulation $\delta\Gamma/(Ua)$ and hydrodynamic impulse $I_s/(2\pi\rho Ua^3)$ with the results of numerical integration for $\varepsilon \in [0.05, 0.35]$. In the numerical calculations, the velocity field (equations 9–10) was integrated using a fourth-order Runge–Kutta method on a 600×600 grid in the meridional half-plane, while the integrals (19) and (12) were evaluated using quadrature methods. The comparison results are shown in Fig. 5.

The agreement between analytical and numerical results is excellent for $\varepsilon < 0.25$ (relative error < 2%). For $\varepsilon > 0.3$, second-order corrections $\mathcal{O}(\varepsilon^2)$ become significant; however, the qualitative behavior (linear scaling with ε) is preserved. This confirms the validity of the Gaussian perturbation model and the accuracy of the closed-form expressions (17), (19), and (23) in the non-destructive regime.

12. Conclusions.

Based on the analysis performed, the following conclusions can be drawn:

(1) **Preservation of structure**. In the non-destructive regime$\varepsilon \ll 1$ the Hill vortex retains its spherical shape and closed streamline topology after absorbing a counter-rotating vortex. The captured structure loses its individuality and is redistributed within the carrier vortex.

(2) **Core formation**. The absorbed vortex induces a vorticity perturbation $\delta\omega_\varphi$ (equation 17), which disrupts the linear profile Ar and creates a localized vortical core of width ~ σ. This effect is absent in all previous analytical studies of perturbations of the Hill vortex.

(3) **Vortex deceleration**. The propagation velocity decreases according to $\Delta U/U \approx I_s/I_H \sim \mathcal{O}(\varepsilon)$, which quantitatively describes the transfer of impulse from the captured counter-propagating vortex..

(4) **Angular momentum**. The absorption of a vortex with transverse swirl generates a previously absent angular momentum $L_z^{(+)} \sim \varepsilon_\theta \rho U a^4$, transforming the Hill vortex from a purely translational into a weakly rotating coherent structure..

(5) **Passive scalar**. The impurity cloud reorganizes along closed potential layers (surfaces ψ = const), forming a stratified, step-like distribution that persists over timescales $t \sim a/U$ until complete mixing occurs. The spiral structure of the cloud is a kinematic signature of the toroidal topology of the streamlines.

(6) **Quantitative verification**. The analytical predictions for $\delta\Gamma$ and I_s agree with the results of numerical integration to within 1-2% for $\varepsilon <$ 0.25, confirming the validity of the first-order model

The results obtained provide an explicit analytical framework for describing vortex absorption within the Euler equations. They are applicable to the study of interactions of coherent vortical structures in turbulent flows, to MHD dynamo models in conducting fluids, and to the theory of passive scalar transport in coherent vortices.

References

1. A.M. Hill (1894) On a spherical vortex. Phil. Trans. R. Soc. London A, 185, 213-245
2. K. Moffatt, D.W. Moore (1978) The response of Hill's spherical vortex to a small axisymmetric disturbance, *J. Fluid Mech:* 87(04):749-769
3. V.V. Meleshko, A.A. Gourjii and T.S. Krasnopol'skaya (2011) Vortex Rings: History and State-of-the-Art. *Journal of mathematical Science*, Vol. 173, No.4, July
4. S. Childress, A.D. Gilbert (1995) Stretch, Twist, Fold: The Fast Dynamo, Springer
5. S. Childress (2004) Topological Fluid Dynamics for Fluid Dynamicists
6. H.K. Moffatt (1978) Magnetic Field Generation in Electrically Conducting Fluids.
7. K. Moffatt. (1969) Degree of knottedness of tangled vortex lines. *J. Fluid Mech*: 35(01): 117-129
8. P.G. Saffman (1992) Vortex Dynamics. Cambridge University Press.
9. T. Maxworthy (1977) Some experimental studies of vortex rings. *J. Fluid Mech.,* 168, 337-362
10. E. Milyute (2023) Investigation of Conformal Mappings in Solving Problems of Vortex Dynamics

SOCIAL SCIENCES

AN EXAMINATION OF SYNONYMY, POLYSEMY, AND HOMONYMY IN LITERARY TRANSLATIONS FROM GERMAN INTO AZERBAIJANI TURKISH IN TERMS OF TRANSLATION EQUIVALENCE

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Abstract

This study examines the significance of synonymy, polysemy, and homonymy in literary translations from German into Azerbaijani Turkish in terms of translation equivalence. The research emphasizes that literary translation is not merely a linguistic transfer; rather, it is a multilayered process that requires the reconstruction of meaning, style, aesthetic structure, and cultural connotations in the target language. Within this framework, the concept of equivalence is addressed not only in terms of dictionary correspondences but also in relation to context, function, emotional tone, and expressive effect.

The study demonstrates that synonymy plays a decisive role in word choice and stylistic transfer in translation; polysemy necessitates context-based meaning analysis; and homonymy directs the translator toward creative strategies, particularly in relation to wordplay, double meanings, and aesthetic structures. Through examples drawn from German source texts and their Azerbaijani Turkish translations, it is shown that these three semantic phenomena directly influence both the preservation of meaning and the continuation of literary effect in the translation process.

The study concludes that translation equivalence in literary translations from German into Azerbaijani Turkish is not a fixed and absolute correspondence, but rather a dynamic balance reconstructed according to context. Semantic structures such as synonymy, polysemy, and homonymy demonstrate that the translator requires not only linguistic competence but also cultural knowledge, aesthetic sensitivity, and interpretive ability. In this respect, the research argues that meaning, style, and cultural function should be evaluated together in literary translation.

Keywords: Literary translation, translation equivalence, synonymy, polysemy, homonymy.

Introduction

Literary translation is regarded as one of the most complex fields of translation studies, requiring the highest level of interpretation. The primary reason for this is that literary texts are not merely linguistic structures that convey information; rather, they shape the reality experienced, perceived, remembered, and aesthetically reconstructed by human beings within a multilayered system of expression. In literary texts, meaning is constructed not only through events and ideas, but also through word choice, rhythm, tone, associations, cultural references, metaphors, and the author's individual style. Therefore, transferring a literary text into another language does not simply involve translating words; it entails reconstructing meaning, aesthetic structure, and the effect of the text on the reader within the target language.

In this context, literary translations from German into Azerbaijani Turkish constitute one of the areas where the problem of linguistic equivalence becomes most evident. This is because German and Azerbaijani Turkish represent not only structures belonging to different language families but also two distinct linguistic and cultural systems that embody different historical experiences, cultural codes, narrative traditions, and discourse habits. This situation necessitates careful consideration not only of meaning but also of style, associative fields, and cultural context during the translation process. In other words, if the aesthetic orientation, emotional intensity, rhythmic structure, and expressive style of the source text are not reconstructed with appropriate equivalents in the target language, the translation may remain linguistically accurate yet literarily incomplete (Aktaş, 1986, p. 31).

When the historical development of translation theories is examined, it can be observed that early approaches tended to address the concept of equivalence primarily at the level of words and structures. Catford's definition of translation as the replacement of textual elements in one language with equivalent elements in another language remained influential in translation studies for a long period (Catford, 1965, p. 20). However, it later became evident that this approach was limited, especially in the case of literary texts. Literary translation cannot be explained merely as a technical operation of finding linguistic correspondences; rather, it requires the creative reproduction of the functional, aesthetic, cultural, and communicative effects of the text within a new linguistic environment. Jakobson's distinction between intralingual, interlingual, and intersemiotic translation demonstrated that translation is not solely a linguistic process but also a cultural and semiotic reconstruction (Jakobson, 1959, pp. 232–233). Similarly, Eco's definition of translation as an "attempt to say the same thing in another language" clearly indicates that translation is not a simple transfer but an intensive act of interpretation and reconstruction (Eco, 2012, p. 173).

Within the framework of literary translation, equivalence should not be considered a fixed and abso-

lute sameness; rather, it should be understood as a dynamic process that is redefined according to the context, genre, function, and aesthetic orientation of the text. Therefore, translation equivalence cannot be reduced merely to the preservation of meaning at the denotative level; it must be approached as a multilayered structure that encompasses connotative, textual, pragmatic, and formal dimensions (Bıçkıcı, 2016, pp. 29–30). In literary texts, the element that needs to be preserved is often not the surface form of words, but the aesthetic tone, emotional core, communicative effect, and stylistic orientation of the text (Yazıcı, 2005, p. 133). In this respect, the balance established between formal equivalence and dynamic equivalence becomes one of the fundamental criteria determining the success of literary translation (Nida, 1964, p. 159; Nida & Taber, 1969, p. 200).

Synonymy, polysemy, and homonymy, which constitute the main focus of this study, are among the primary semantic phenomena that play a decisive role in achieving translation equivalence. Synonymy represents an important domain in determining which lexical choices in the target language can reflect the nuances of meaning, emotional tone, and stylistic variations present in the source text. Polysemy directs the translator toward context-based semantic analysis, as a single lexical unit may acquire different layers of meaning depending on context. Homonymy, particularly in literary texts containing wordplay, puns, humor, and double meanings, raises the question of how the relationship between form and meaning can be reconstructed in the target language. These three linguistic structures require not only semantic analysis but also influence translation decisions regarding how the aesthetic and cultural functions of the text can be preserved.

Word choice, in this respect, constitutes one of the central concepts of this study. In literary texts, each word does not merely denote a concept; it also carries a particular emotion, association, rhythm, cultural value, and stylistic function. An incorrect or insufficient lexical choice may damage not only the meaning of the text but also its atmosphere, character voices, narrative tone, and cultural depth. Especially in texts rich in national and cultural elements, significant differences may exist between the dictionary meanings of words and their historical and cultural connotations. Therefore, the translator should not be satisfied with selecting the closest lexical equivalent; instead, they must determine the most appropriate equivalent in functional and stylistic terms by considering the context, cultural background, and aesthetic orientation of the source text (Gudykunst, Ting-Toomey & Nishida, 1996, p. 4; Newmark, 1988, p. 94).

Based on these considerations, the present study, entitled **"An Examination of Synonymy, Polysemy, and Homonymy in Literary Translations from German into Azerbaijani Turkish in Terms of Translation Equivalence,"** aims to reveal the functions of these three semantic phenomena in the translation process, the challenges they create, and the problems they generate in terms of equivalence. The study seeks to evaluate synonymy, polysemy, and homonymy not only as linguistic categories but also as structures that play an active role in reconstructing meaning, style, and cultural context in literary translation. Accordingly, the research examines the relationship between German source texts and their Azerbaijani Turkish translations at semantic, stylistic, and cultural levels, discussing how translation equivalence is established and under what conditions it becomes weakened.

Synonymy and Translation Equivalence in Literary Translation from German into Azerbaijani Turkish

Although synonymy is one of the most frequently discussed concepts in semantics, it is also one of the linguistic phenomena whose boundaries are most difficult to define. In general terms, synonymy is defined as the sharing of the same or very similar semantic fields by different linguistic units; however, there is no complete consensus among linguists regarding the nature of this relationship. Lyons explains synonymy through the criterion that replacing one linguistic unit with another should not cause any change in the meaning of the sentence, and he considers such meaning-preserving substitutions to fall within the scope of synonymy (1983, p. 382). Murphy approaches synonymy as a relationship between words that are similar in meaning (2003, p. 133), while Riemer emphasizes the condition in which the meanings of two words overlap or are identical (2010, p. 150). Bussmann defines this concept as a semantic relationship that demonstrates strong similarity or identity between the meanings of two or more linguistic expressions (1998, p. 1165). In Lyons' later work, synonymy is again regarded as a relationship between linguistic expressions that share the same meaning, with semantic overlap considered its primary determinant (1995, p. 60). When these definitions are considered together, it becomes evident that synonymy is not a single-dimensional or absolute linguistic phenomenon; rather, it exhibits a multidimensional structure that involves layers such as meaning, usage, context, and style.

Vardar and other researchers, along with Günay, explain synonymy as the expression of the same meaning by two or more linguistic signs; in other words, different signifiers correspond to the same signified (Vardar et al., 2002; Günay, 2007). This perspective indicates that synonymy should not be examined merely as a formal relationship between words but rather within the framework of the relationship between signifier and signified. Lipka also emphasizes that synonymy is not established directly between words themselves but between lexical meaning units, arguing that this phenomenon should be understood not simply as "word synonymy" but as "semantic synonymy" (2002, p. 160). Murphy's approach, particularly developed through polysemous words, supports this view; according to him, synonymic relationships may change depending on context, and different meaning layers of the same word may form distinct synonymic networks (Murphy, 2003, pp. 29, 30). Therefore, synonymy is not a static or absolute structure but rather a dynamic semantic relationship that is reshaped according to context.

Within the vocabulary of a language, there are many lexical units that are close in meaning and sometimes overlap to a certain extent. Examples such as *demək* ("to say") and *söyləmək* ("to tell"), or *göndərmək* ("to send") and *yollamaq* ("to dispatch"), demonstrate

the existence of linguistic units that share the same conceptual field but are not entirely identical. Similarly, in Turkish, words such as *qəlb* and *ürək* ("heart"), *xoşbəxt* and *məsud* ("happy"), and *ağıl* and *zehin* ("mind") are frequently cited in discussions of synonymy. However, complete synonymy is extremely rare in natural languages, because each word carries not only its basic meaning but also its associative value, usage domain, emotional tone, and stylistic characteristics, which together form its unique identity. For instance, although *ölmək* ("to die") and *vəfat etmək* ("to pass away") refer to the same fundamental phenomenon, the latter carries a more formal and respectful connotation. This situation clearly demonstrates that the concept of synonymy cannot be explained solely through semantic similarity; rather, it must be evaluated together with elements such as context of use, discourse type, and stylistic features.

Synonymy is not only a lexical category but also a semantic and stylistic system that organizes the expressive possibilities of language. Words that are close in meaning are used extensively, particularly in literary texts, to enhance the aesthetic power of expression, expand descriptive capacity, reduce repetition, and add subtlety to linguistic expression. In this respect, synonyms constitute one of the fundamental tools that broaden the expressive capacity of a language. The diversity offered by synonyms is considered an indicator of the richness of meaning within a language; it enables ideas to be expressed in more detailed, effective, and nuanced ways in both native and foreign language use. Therefore, the function of synonyms is not limited merely to expanding vocabulary; it also strengthens the aesthetic, cultural, and pragmatic dimensions of language.

From a **semasiological** perspective, synonymy refers to the relationship between lexical units that are written or pronounced differently but share a certain degree of semantic similarity. Examples from Azerbaijani Turkish such as *qaçmaq–yüyürmək* ("to run"), *oturmaq–əyləşmək* ("to sit"), and *danışmaq–dinmək* ("to speak") illustrate structures in which formal difference and semantic proximity coexist. However, as emphasized by **Əfəndiyeva**, synonyms are not units that can completely replace one another; each element within a synonymic set possesses its own semantic nuance, stylistic value, and functional purpose (Əfəndiyeva, 1980, p. 31–32). Therefore, synonymy does not represent absolute identity but rather a relationship based on graded similarity and contextual appropriateness in most cases.

In evaluating synonymy, **Lyons** builds upon **Stephen Ullmann's** concept of absolute synonymy and particularly focuses on cognitive synonymy. According to Lyons, if there is complete overlap both in cognitive meaning and emotional value, the relationship may be considered absolute synonymy. By contrast, the possibility of substituting words for one another in all contexts is explained through total synonymy. Considering these two criteria together, Lyons proposes that synonymy may occur at four different levels: absolute and total synonymy, absolute but non-total synonymy, non-absolute but total synonymy, and neither absolute nor total synonymy (1983, pp. 399–400). This classification is important because it demonstrates that synonymy is not limited merely to semantic similarity; rather, it is graded according to contextual scope, domain of usage, and semantic functions.

At this point, **Collinson's** classification of the differences that may arise among synonyms into nine categories is also noteworthy. According to Collinson, one synonym may carry a more general or more specific meaning than another; it may exhibit stronger emotional intensity, a more neutral association, moral approval or disapproval, professional usage, literary character, features of everyday speech, regional variation, or characteristics specific to children's language (Ullmann, 1972). This approach reveals that synonymic relationships include not only semantic but also pragmatic and socio-stylistic differences.

Alan Cruse also evaluates synonymy not as a fixed and absolute relationship but as a graded form of semantic proximity. According to him, while some lexical units display a high degree of similarity, others exhibit a more limited level of semantic closeness; therefore, some word pairs may be considered "more synonymous" than others (1987, p. 265). Cruse categorizes synonymy into three primary levels: total synonymy, cognitive synonymy, and near synonymy (1987). In particular, near synonymy is the most common relationship found in natural languages; in such cases, words are very close in meaning but not entirely identical. Lyons similarly uses the concept of near synonymy to describe linguistic expressions that approach one another in meaning but are not completely identical (1995, p. 60). As **Murphy** notes, since most synonymous elements contain certain differences in terms of their contribution to truth conditions, natural languages generally display high degrees of semantic similarity rather than absolute identity (Murphy, 2003, p. 147).

Bloomfield's view that formal difference necessarily implies semantic difference is based on the assumption that true absolute synonymy is not possible in natural languages (Ullmann, 1972, p. 141). In contrast, Ullmann suggests that, particularly in scientific and technical terminology, there may be rare cases of units that completely overlap in cognitive meaning and do not differ in emotional associations (1972, p. 141–142). Nevertheless, considering the dynamic nature of natural language, it can be observed that linguistic units that are entirely synonymous cannot coexist indefinitely. As indicated by Lyons and Cruse, whether such units enter a language through borrowing or emerge among native elements, over time one of these units may fall out of use, or each may acquire different semantic functions and diverge from one another (Cruse, 1987, pp. 268). In this way, the principle of linguistic economy leads to the gradual differentiation of synonymous units over the long term.

Total synonymy is defined by **Ullmann** as the ability of two words to be used interchangeably in all contexts without any difference in either cognitive or emotional meaning (1972). **Lyons**, on the other hand, proposes three conditions that must be met in order to claim the existence of such synonymy: the meanings of the relevant units must completely overlap, they must be interchangeable in every context, and they must demonstrate equivalence not only in cognitive meaning

but also in non-cognitive dimensions of meaning (1995, p. 61). In contrast, **cognitive synonymy** is explained primarily on the basis of truth conditions. Lyons' substitution criterion is also significant in this context; if replacing one linguistic unit with another does not alter the meaning of the sentence, the two elements may be considered cognitively equivalent (1983, p. 382). **Alan Cruse** similarly states that if elements X and Y occupy the same syntactic position and the truth conditions of a sentence containing X remain unchanged when Y is used instead, these two elements can be regarded as synonymous (1987, p. 88). This approach demonstrates that synonymy should be evaluated not only according to dictionary correspondences but also in terms of semantic function at the sentence level.

Leech's classification of meaning into seven categories-conceptual, associative, social, affective, reflected, collocative, and thematic-further deepens discussions of synonymy (Persson, 1990, p. 94). In this model, synonymy requires consideration not only of core conceptual meaning but also of secondary layers of meaning. **Persson**, similarly to Lyons, examines synonymy both at the lexical and sentence levels, emphasizing that sentence-level synonymy depends not only on lexical substitution but also on structural compatibility (Persson, 1990, pp. 94, 135). For example, in sentences such as *Mary hid the truth from Tom* and *Mary concealed the truth from Tom*, if different lexical choices preserve meaning within the same structural framework, sentence-level synonymy can be observed (Persson, 1990, p. 135). This point demonstrates that in translation studies, synonymy can be established not only between individual words but also across broader syntactic and semantic patterns.

Since synonymy represents a relationship that often gains meaning within context rather than constituting an absolute identity independent of context, idioms, proverbs, and fixed expressions clearly illustrate the limits of this concept. For instance, word pairs such as *ağ* and *bəyaz* ("white"), and *qəlb* and *ürək* ("heart") may appear similar in general meaning; however, they cannot replace one another within fixed expressions. In the proverb *"Ağ ağça qara gün üçündür"* ("Save white coins for dark days"), it is not possible to substitute *ağ* with *bəyaz*. Similarly, in the expression *"alnı açıq, üzü ağ"*, the word *ağ* carries an established semantic and cultural value. These examples demonstrate that synonymy is closely connected to cultural tradition, discourse habits, and the fixed structures of language.

The functions of synonyms are not limited to providing semantic similarity. As a lexical-semantic category, synonyms enrich both spoken and written language, reduce repetition, enhance clarity and expressive impact, and strengthen the rhythm and emotional intensity of a text. In literary texts, the consecutive or combined use of synonyms constitutes an important stylistic technique that intensifies meaning, strengthens rhythm, and heightens aesthetic effect. Moreover, synonyms play significant roles in constructing figurative expressions such as metonymy, epithets, and metaphors. Expressions such as *"Odlar Yurdu – Azerbaijan"* ("Land of Fire – Azerbaijan"), *"qara qızıl – neft"* ("black gold – oil"), *"ağ qızıl – pambıq"* ("white gold – cotton"), and *"Küləklər şəhəri – Bakı"* ("City of Winds – Baku") represent examples of synonymic usage with strong metaphorical and cultural associations (Əliyeva, 2018, p. 12). In this way, synonyms move beyond being merely elements that expand vocabulary and become carriers of cultural imagination and aesthetic expression.

Riesel's classification of synonyms into two main groups-lexical and grammatical-and her distinction within lexical synonyms between ideographic and stylistic types makes the functional dimension of synonymy more visible (Riesel, 1954, pp. 44–51). Similarly, **Həsənov's** distinction between absolute and relative synonyms highlights the graded nature of synonymic relationships (Həsənov, 2001, p. 94). As emphasized by **Əfəndiyeva**, literary language norms, dialectal and regional elements, colloquial speech, borrowings, archaisms, slang elements, phraseological structures, and idiomatic combinations constitute the primary sources that expand the field of synonymy (Əfəndiyeva, 2001, p. 16). This situation is particularly significant in the field of translation, as translators must work not only with dictionary-recorded equivalents but also with the historical, cultural, and stylistic layers of language.

Qurbanov also emphasizes that synonymy constitutes one of the fundamental pillars of stylistics, highlighting that synonyms enrich expression at the level of words, phrases, and sentences. According to him, lexical synonyms play a decisive role in expressing thought in a more detailed, aesthetic, and effective manner. Series such as *dayanmaq / durmaq / ayaq saxlamaq* ("to stop / to stand still / to halt"), *sevmək / vurulmaq / aşiq olmaq* ("to love / to become fond of / to fall in love"), *eşitmək / dinləmək / qulaq asmaq* ("to hear / to listen / to pay attention"), and *kömək etmək / dayaq olmaq / dəstəkləmək* ("to help / to support / to back up") provide a variety of semantic and stylistic nuances within the same conceptual field. As Qurbanov notes, some synonymic series are also functional in producing positive or negative connotations; cacophemism and euphemism represent clear examples of this function (Qurbanov, 1985, p. 306). As **Babayev** further points out, selecting the most appropriate expressive unit requires a thorough understanding of the structural and functional characteristics of semantically related linguistic elements; not every lexical item used in everyday language can be employed with the same effect in literary language (Babayev, 2001, pp. 45–50). In this context, synonym selection is not merely a grammatical preference but also an aesthetic and pragmatic decision-making process.

This theoretical framework becomes particularly evident in literary translations from German into Azerbaijani Turkish. In the translation process, synonymy is not simply a matter of finding an equivalent word in another language; it is directly related to preserving the emotional tone, aesthetic structure, rhythm, and expressive style of the text. Since it is often impossible to find an exact equivalent for a source-language word in the target language, the translator must select the synonym that best fits the context, discourse type, and overall atmosphere of the text. Therefore, from the perspective of translation studies, synonymy extends beyond the transfer of meaning and becomes one of the central tools for transferring style.

One of the most significant dimensions of synonym usage in literary translation is the preservation of emotional tone. Minor differences in connotation between words may significantly alter the emotional effect of a text on the reader. Just as the difference between *hüzün* ("melancholy") and *kədər* ("sorrow"), or *qorxu* ("fear") and *dəhşət* ("terror"), changes the level of emotional intensity in Turkish, similar sensitivity is required when transferring German expressions into Azerbaijani Turkish. Therefore, the translator must take into account not only the core meaning but also the emotional load carried by the word. Otherwise, the original atmosphere of the text may weaken or a different aesthetic effect may emerge in the target language.

The rhythm and aesthetic structure of the text also play a decisive role in synonym selection. Particularly in poetic or stylistically dense literary expressions, the syllabic structure, sound value, stress, and flow of a word within the sentence are as important as its meaning. For this reason, a translator may sometimes prefer a synonym that better suits the rhythm and aesthetic harmony of the text rather than the word that appears to be the closest in meaning. Such a choice makes the translation not only accurate but also literarily effective. In this respect, synonymy functions as a creative tool that enables both semantic fidelity and aesthetic reconstruction in literary translation.

Translation examples from **Stefan Zweig** clearly illustrate this situation. In the sentence *"Bisher hatte er, einsam erzogen und oft kränklich, wenig Freunde gehabt..."*, rendered into Azerbaijani Turkish as *"Bu vaxta qədər həmişə yalqız, tez-tez də xəstə olmuşdu, dostu da az idi..."*, the translator did not rely solely on lexical equivalence; instead, emotionally charged expressions such as *"Zärtlichkeitsbedürfnis"*, *"Enttäuschungen"*, and *"Einsamkeit"* were reconstructed in the target language through synonymous and stylistically appropriate equivalents capable of producing a similar effect (Zweig, 1986, p. 20; Svayq, 2010, p. 172). Here, synonym selection is directed not only at preserving semantic content but also at maintaining the emotional tone and psychological depth of the text.

A similar situation can be observed in the translation of the sentence *"Er kam mir nicht einen Schritt entgegen, und ich musste-ein wenig befremdet-bis an ihn heran, um seine Hand zu fassen."* The verb *"befremdet"* in the source language primarily conveys meanings such as "surprised," "alienated," or "unsettled." However, the translator rendered this expression as *"çəkinə-çəkinə, qısqana-qısqana"*, creating a stronger synonymic sequence in the target language rather than using a single dictionary equivalent (Zweig, 1986, p. 412; Svayq, 2010, p. 436). Thus, the translation conveys not only meaning but also the character's internal tension and emotional hesitation. This example clearly demonstrates that synonymy in translation is not a mechanical dictionary operation but a contextual and artistic process of selection.

Translations of **Franz Kafka** are also noteworthy in this respect. The rendering of the verb *"aufsteigen"* as *"şahə qalxmaq"* and *"schweben"* as *"cövlan etmək"* indicates that the translator did not adhere strictly to dictionary equivalents but instead selected creative synonyms capable of preserving the sense of movement, elevation, and aesthetic dynamism within the text (Kafka, 1983, p. 240; Kafka, 2010, p. 392). Similarly, translating the word *"der Führer"* as *"köşəkçi"* in accordance with context demonstrates that contextual and cultural equivalence was prioritized over mere lexical equivalence. As noted by **Əfəndiyeva**, existing synonymic series may sometimes fail to meet the expressive requirements of the translator; in such cases, translators may create individual stylistic synonyms that correspond to the aesthetic and stylistic features of the text (Əfəndiyeva, 1980, p. 41). The Kafka example can be regarded as a successful implementation of such creative intervention.

The translation relationship between German and Azerbaijani Turkish also reveals the complexity of synonymy, particularly in verb sequences. Verb series such as *schleichen – schlurfen – schreiten*, *wandeln – trotteln – wandern*, *marschieren – stapfen – gehen*, *huschen – eilen – hasten*, *laufen – spurten – sprinten*, and *stürmen – rennen – sausen* represent different speeds, manners, purposes, body movements, and stylistic values within the same general field of motion. When translating these verbs into Azerbaijani Turkish, relying solely on general equivalents such as *getmək* ("to go"), *qaçmaq* ("to run"), or *addımlamaq* ("to step") is often insufficient. Each verb contains not only a core semantic meaning but also specific secondary meanings and usage conditions. For example, *schleichen* may convey "to creep" or "to approach slowly," *schlurfen* may indicate "to walk dragging one's feet," while *schreiten* may mean "to stride" or metaphorically "to proceed into an action." Similarly, verbs such as *wandeln*, *wandern*, *trotten*, *gehen*, and *huschen* also include multiple semantic variants. This network of polysemy and near synonymy requires the translator to possess deep knowledge not only of two languages but also of their semantic and stylistic systems.

Löbner's distinction between absolute and relative synonyms is also illuminating in this regard. According to him, absolute synonyms are words largely free from semantic variation, capable of replacing one another without loss in context, and exhibiting a high degree of semantic equivalence; examples include the German pairs *Samstag–Sonnabend* and *Cousin–Vetter* (Löbner, 2003, p. 117). Relative synonyms, by contrast, intersect only within certain semantic fields but diverge in various meaning variants. This latter structure is the most frequently encountered in translation practice. Particularly in literary texts, words often function not through their dictionary meanings but through the associative values they acquire within context. Therefore, instead of reproducing each synonymic series in the source language in exactly the same way, the translator must construct a new network of synonyms in the target language that ensures functional and aesthetic equivalence.

Polysemy and Contextual Meaning Transfer in Literary Translation from German into Azerbaijani Turkish

In linguistics, the condition in which a word corresponds to only a single meaning and refers to a single referent is defined as **monosemy**. Such words are regarded as linguistic units that do not create semantic ambiguity and enable clear and precise communication;

for this reason, they find more functional use particularly in scientific and technical fields (Bilgin, 2002, p. 29). In contrast, the condition in which a word contains more than one meaning is referred to as **polysemy**. Polysemy is a dynamic process that emerges throughout the historical development of language, as words acquire new functions in new contexts, existing semantic fields expand, and new layers of meaning develop around a core meaning. Therefore, polysemy is considered one of the clearest indicators that language is not static but rather a living structure that continuously develops and changes.

In traditional linguistic approaches, lexical ambiguity has often been examined together with homonymy; however, polysemy occupies a distinctive place within this framework. This is because polysemy refers to the presence of multiple related meanings within the same lexical unit. These meanings are not entirely disconnected from one another; on the contrary, in most cases they develop around a shared conceptual core or basic meaning. As Gürlek points out, polysemy emerges as a natural consequence of the expansion of meaning and its adaptation to new contexts within language (Gürlek, 2016, p. 173). For this reason, polysemy should not be understood merely as a superficial phenomenon in which a word has multiple meanings; rather, it should be regarded as an important semantic mechanism that reflects the capacity of language users to form analogies, make abstractions, establish associations, and generate new meanings.

One of the fundamental approaches explaining the functioning of polysemy is based on the view that each word initially emerges with a single meaning, but over time acquires new meanings in response to the communicative needs and experiences of language users. According to Acar, polysemy refers to the situation in which a linguistic sign not only carries its primary meaning but also becomes capable of representing new concepts under the influence of various factors (Acar, 2010, p. 242). This perspective explains polysemy not as the random emergence of entirely new meanings, but as the development of new meanings that remain connected to an existing core meaning. Indeed, the fact that the term *polysemy* was first addressed scientifically by **Michel Bréal** in 1887 indicates that polysemy began to be viewed as a phenomenon closely associated with historical language change and semantic expansion. Derived from the Greek elements *poly* (“many”) and *sema* (“sign”), the term refers to the ability of a linguistic unit to express more than one meaning (İsmayılova, 2022, p. 6).

The concept of polysemy is explained through the development of new layers of meaning around a core meaning without the loss of the original sense. As Həsənov notes, the initial meaning of a word does not disappear; rather, it functions as a reference point in the formation of new meanings (Həsənov, 1978, p. 37). Therefore, in polysemous words, there exists a relationship of continuity between the core meaning and the secondary meanings that develop from it. As illustrated in the examples provided by Cəfərov, words such as *qaşqa*, *traktor*, *orfoqrafiya*, and *kombayn*, which are used to denote specific concepts, remain monosemous structures; however, the word *ağız* (“mouth”) acquires new meanings derived from its primary sense, as in expressions such as *bıçağın ağzı* (“the blade of a knife”), *topun ağzı* (“the muzzle of a cannon”), *qapının ağzı* (“the doorway”), and *qazanın ağzı* (“the opening of a pot”), thus becoming a polysemous structure (Cəfərov, 2007, p. 16). Such examples demonstrate that semantic expansion in language often develops from a concrete conceptual core.

Polysemy is a linguistic phenomenon widely observed in almost all natural languages. Words referring to human body parts and basic everyday objects are particularly productive structures in terms of polysemy. For instance, in Turkish, the word *baş* (“head”), in addition to its primary meaning referring to a human body organ, can also be used in different senses such as “beginning,” “the head of a task,” “the top of a mountain,” and “leader.” Similarly, the word *göz* (“eye”) refers not only to the organ of vision but also to different concepts such as *iynə gözü* (“eye of a needle”), *qaynağın gözü* (“spring source”), and *pəncərə gözü* (“window pane”). Each of these meanings develops directly or indirectly through shared conceptual links such as openness, focus, hole, sight, or center. As Acar points out, the widespread nature of polysemy in natural languages has led some linguists to conclude that a significant portion-if not nearly all-of the lexicon exhibits polysemous characteristics to varying degrees (Acar, 2010, p. 242).

One of the primary processes involved in the formation of polysemy is **semantic extension**. The core meaning of a word is transferred over time to other conceptual domains through metaphor, analogy, abstraction, association, social usage, and contextual shifts. For example, the word *üz* (“face”) in the sentence *“Divan üzünün dəyişməsi lazımdır”* (“The surface of the armchair needs to be changed”) is used in the sense of surface, whereas in the expression *“Bu adamda üz yoxdur ki”* (“This man has no shame”), it acquires a metaphorical meaning referring to the absence of shame or modesty. In the first example, the similarity between the human face and the outer surface of objects forms the basis of meaning transfer; in the second example, the association between shame and facial expression underlies the semantic shift (Gürlek, 2016, p. 173). In this way, a physical characteristic is transferred into a social or emotional domain, and the word assumes new functions in different contexts. The same mechanism can be observed in many words such as *ağız* (“mouth”), *qol* (“arm”), *yük* (“load”), *göz* (“eye”), and *baş* (“head”).

As Kahraman notes, a significant portion of metaphorical meanings, idiomatic expressions, technical terms, and slang expressions also emerge as a result of semantic extension and should therefore be evaluated within the framework of polysemy (Kahraman, 2015, pp. 15–16). Consequently, polysemy is not merely a collection of multiple meanings listed side by side in a dictionary; it is also a model of meaning production that reflects the creative functioning of language, cultural experience, and the capacity for abstraction. This perspective demonstrates that polysemy is not only a semantic process but also a cultural and cognitive one.

Filizok's classification of polysemy into three main groups according to its formation processes provides a more systematic explanation of this phenomenon. The first group consists of polysemy derived from the primary meaning; here, the original meaning of the word gradually adapts to different contexts, leading to the emergence of new meanings. The second group involves a multilayered structure in which one primary meaning coexists with one or more secondary meanings; in this case, the original meaning is preserved while associative and metaphorical meanings come into use. The third group consists of polysemy arising from stylistic deviation; this type, commonly observed in literary texts, emerges as a result of deliberate departure from standard language usage and serves to enhance aesthetic effect (Filizok, 2001, pp. 132–133). This classification demonstrates that polysemy should be evaluated not only at the dictionary level but also at the level of usage and style.

Social and psychological factors also play an important role in the development of polysemy. As emphasized by Xanəliyeva, the use of words in different ways by various social groups leads the same lexical unit to acquire new semantic content across different social and cultural contexts (Xanəliyeva, 2023, p. 280). Professional jargon, social environments, generational differences in usage, and cultural norms can directly influence the diversification of word meanings. In addition, taboos, fear, religious prohibitions, and the need for indirect expression also create conditions for the emergence of new layers of meaning. In societies where the direct expression of certain concepts is considered inappropriate or undesirable, new indirect expressions emerge to represent these concepts; thus, semantic expansion gradually develops into polysemy (Xanəliyeva, 2023, p. 280).

Internal linguistic factors are equally influential in the formation of polysemy. The gradual shortening of fixed expressions, ellipsis structures, conventional collocations, and semantic convergence may lead words to acquire new meanings. In cases where an expression initially consists of multiple components but gradually becomes shortened so that a single word assumes the meaning of the whole expression, polysemy emerges through internal linguistic mechanisms (Xanəliyeva, 2023, p. 280). This demonstrates that polysemy does not arise solely from relationships established with objects and events in the external world, but also from the internal functioning of the language system itself.

One important perspective on polysemy is the view that it develops naturally around a conceptual center. The core meaning of a word is not only historically its first meaning but also constitutes the neutral semantic field from which new meanings emerge. The social experiences and cognitive associative networks of language users enable new connections to be formed around this central meaning. Therefore, polysemy should not be regarded as a collection of randomly multiplied meanings; rather, it represents the linguistic reflection of conceptual thinking and the capacity to generate meaning. As Cəfərov points out, this situation does not indicate the inadequacy of language; on the contrary, it demonstrates the richness of its expressive power and creative capacity (Cəfərov, 1982, p. 97).

The belief that polysemy always creates confusion in communication is considered an incomplete evaluation from a linguistic perspective. According to Qurbanov, the presence of multiple meanings within a word does not in itself cause semantic confusion; the decisive factor is context (Qurbanov, 2019, p. 331). The meaning in which a word is used usually becomes clear through its relationship with other elements within the sentence. Therefore, polysemy should be regarded not as a defect that complicates communication but as a flexible and productive linguistic feature that operates through context. Indeed, if natural languages consisted entirely of monosemous words governed by rigid rules, flexibility in meaning interpretation would disappear, and the creative and aesthetic potential of language would be significantly restricted (Kahraman, 2015, p. 17).

At this point, **context-based semantic analysis** emerges as a fundamental method for correctly understanding polysemous words. The true meaning of a word cannot be determined solely by its dictionary definitions; it must also be considered in terms of the context in which it is used, its communicative purpose, and the nature of the interactional setting. Linguistic context refers to the relationships between the word and other elements within the sentence, whereas situational context includes the social, cultural, and communicative environment.

Context-based semantic analysis becomes even more critical in the translation process. In order to find the correct equivalent for a polysemous word in the source language, consulting dictionary meanings alone is insufficient; the function of the word within the text, the genre of the text, the author's intention, and the overall atmosphere of the text must also be taken into consideration. Particularly in literary translation, misinterpretation of context may lead to semantic shifts, the weakening of imagery, and the distortion of the author's stylistic features. Therefore, when encountering polysemy, the translator must evaluate the semantic field of the word, its associative value, and its role within the text simultaneously.

This situation becomes even more evident in literary translations from German into Azerbaijani Turkish. This is because between the two languages, not only the basic meanings of words but also their secondary meanings, associative fields, cultural functions, and metaphorical uses do not always correspond directly. As indicated in Qurbanov's example, even the semantic range of the Azerbaijani Turkish word *göz* does not fully correspond to the Russian *glaza*, making it natural that such semantic shifts become even more pronounced between German and Azerbaijani Turkish (Qurbanov, 2019, p. 331). Consequently, the closest equivalent of a polysemous word in one language may not carry the same layers of meaning in another language. This situation directs the translator away from seeking direct lexical equivalence and toward finding contextually appropriate functional equivalence.

One of the major problems encountered in translating polysemous words is the difficulty of fully transferring secondary meanings and associative values into

the target language. Although the core meaning of a word may appear translatable, its emotional load, cultural associations, or imagistic effect may not be conveyed with the same intensity in the target language. This loss becomes even more pronounced in literary texts, as literary language is often constructed not through direct expression but through associations, imagery, and multilayered semantic relations. Therefore, preserving only the core meaning in translation is insufficient; secondary meanings and aesthetic functions must also be conveyed to the target language as effectively as possible.

The transfer of metaphorical meanings also represents a significant challenge within the framework of polysemy. Many polysemous words acquire new layers of meaning through metaphorical extension. Translating a metaphor directly does not always produce the same effect; in such cases, the translator must either find another figurative structure in the target language that performs a similar function or develop an explanatory expression that preserves the meaning. However, such intervention carries the risk of altering the aesthetic structure of the text. For this reason, the translator's task in literary translation is not limited to semantic transfer but also includes producing creative solutions capable of preserving the rhythm, tone, and emotional atmosphere of figurative language.

Preserving figurative language is a decisive criterion in the translation of polysemous words. Especially in poetic and literary expression, images of nature, colors, objects, and body parts are often used not only in their literal meanings but also with broader associative fields. In transferring such expressions into the target language, literal translation may sometimes render the text meaningless or weaken its aesthetic impact. Therefore, the translator must select elements in the target language that preserve the meaning of the text while producing a similar emotional and aesthetic effect.

The German word *grau* provides a striking example within this framework. In terms of dictionary meaning, this word carries various senses such as the color gray, gloom, uncertainty, and hopelessness, and it can acquire quite different semantic layers depending on context. In examples drawn from Remarque's works, it is observed that the word *grau* was not translated directly into Azerbaijani Turkish as *boz* ("gray"); instead, it was rendered using different equivalents required by the context. The expression *"grauem, verließendem Glanz"* was translated as *"tutqun parıltılı"* ("dimly shining"); *"im rieselnden Grau"* as *"çənli-çiskinli havada"* ("in misty-drizzly weather"); *"grauer Morgen"* as *"tutqun bir səhər"* ("a gloomy morning"); *"das Meer ... war grau"* as *"bomboz dəniz"* ("a completely gray sea"); and *"Das Mädchen lag grau in den Kissen"* as *"Qızın solğun bənizi yastıqdan güclə seçilirdi"* ("The girl's pale complexion was barely distinguishable from the pillow"). These examples demonstrate that the translator took into account not only the basic color meaning of the word but also the emotional and visual layers formed according to context (Remarque, 1976, pp. 5, 10, 16, 38, 188; Remark, 2009, pp. 15, 19, 25, 50, 212). Such examples reveal that contextual interpretation is essential in translating polysemous words and that, in some cases, methods such as substitution, expansion, or adaptation must be employed instead of literal translation.

Similarly, the translation of the word *grauhaarig* as *"çalbaş"* is also noteworthy. Although the source-language meaning of this word corresponds to "gray-haired," rendering it as *"çalbaş"* in the target language, while somewhat departing from direct equivalence, may be considered a more natural choice in terms of usage norms and stylistic expectations of the target language (Zweig, 1986, p. 155; Svayq, 2010, p. 314). Such examples indicate that the translator considers not only semantic accuracy but also naturalness of expression and aesthetic harmony in the target language.

Another example from Remarque's work involving the word *Sack* clearly demonstrates how polysemy can create difficulties in translation: in the expression *"...fiel die Müdigkeit ... über seinen Kopf wie ein Sack"*, the word *Sack* carries not only the dictionary meanings "bag" or "sack" but is also open to figurative usage. However, instead of translating this element literally, the translator preferred the expression *"başına yorğunluq ələnir"* ("fatigue sifted down onto his head"), thereby attempting to preserve the sense of sudden collapse in the source text while creating a natural and effective expression in the target language (Remarque, 1976, p. 6; Remark, 2009, p. 15). In this case, it is evident that the translator anticipated that carrying over the dictionary equivalent literally would sound artificial in the target language and therefore performed a contextually appropriate transformation. Such interventions demonstrate that polysemy in literary translation constitutes not only a semantic but also a stylistic decision-making domain.

Likewise, in the example involving the words *Karton* and *Flamme*, the translator did not attempt to render every polysemous element in the source language directly into the target language; instead, attention was given to expressive economy and fluency. Although the word *die Flamme* means "flame," the most significant element in the sentence is the action of protecting it from the wind. The translator conveyed this scene without explicitly using the word "flame" in the target language, allowing the context itself to complete the meaning (Remarque, 1976, p. 6; Remark, 2009, p. 15). This approach shows that dealing with polysemy in translation does not always involve finding direct equivalents; sometimes certain elements may be omitted by relying on the contextual strength of the text.

The view of Verdiyeva, Ağayeva, and Adilov that polysemy should be regarded not as a property of individual words but as a feature of lexical structure is also significant for translation studies. According to them, each distinct meaning of a lexeme should be considered a *sememe*, and the structural characteristics of these sememes must be examined in detail in order to fully understand the phenomenon of polysemy (Verdiyeva, 1979, p. 295). As noted by Veysəlli, the formation of secondary meanings in polysemous words is often based either on functional similarities or formal characteristics (Veysəlli, 2013, p. 151). Dəmirçizadə also emphasizes that many words in a language gradually move from a monosemous structure to lexical units functioning across multiple semantic fields (Dəmirçizadə, 1962,

p. 152). Qurbanov further states that this process accelerates particularly through metaphorical usage and that metaphorical expansion constitutes one of the primary sources of polysemy (Qurbanov, 1985, p. 289).

Cruse's distinction between linear and non-linear polysemy also provides a useful framework for literary translation. In linear polysemy, meanings are connected through systematic and hierarchical relations, whereas in non-linear polysemy, relationships are primarily based on metaphor, metonymy, and associative links. In literary texts, translators are usually challenged more by the second type. This is because, in non-linear polysemy, the connection between different layers of meaning is not immediately visible; rather, it is perceived through the reader's associative field and the aesthetic texture of the text. In such cases, the translator's task is not merely to transfer the apparent meaning of the word but also to reconstruct its associative load within the target language.

Homonymy, Wordplay, and Aesthetic Equivalence in Literary Translation from German into Azerbaijani Turkish

Among the semantic phenomena that are closely associated with polysemy in the lexical system of language, yet possess structural characteristics distinct from it, one of the most significant is homonymy, also referred to as homophony. In linguistics, the term *homonymy*, derived from the Greek *homonymia*, is defined as the occurrence of different linguistic units that are unrelated in meaning but identical in sound or spelling. Within this framework, lexical homonyms are words that do not share a common semantic component, lack associative or conceptual connections, yet possess the same phonetic structure (Xanəliyeva, 2023, p. 282). Homonymy represents a type of semantic ambiguity frequently encountered in natural languages and is directly connected to both the historical development of language and the complex relationship between form and meaning.

Although various definitions of homonyms exist in linguistic literature, the commonly accepted fundamental characteristic is that words share identical spelling and/or pronunciation while differing completely in meaning. According to Həsənov, homonyms are phonetically identical words whose lexical meanings differ and whose grammatical properties may sometimes be either similar or distinct (Həsənov, 1990, p. 43). Hartmann and James likewise describe homonymy as the relationship between words that are identical in form but differ in meaning (Hartmann & James, 1998, p. 69). Similarly, Lakoff and Johnson emphasize that the same word form may be used to express different concepts, noting that homonymy is closely related to the conceptual organization of language (Lakoff & Johnson, 2010, p. 140). Toklu defines homonymy as the phenomenon in which a single linguistic sign with the same form corresponds to two or more distinct concepts (Toklu, 2003, p. 93), while Ricoeur explains it as the representation of multiple independent meanings by a single name (Ricoeur, 2003, p. 131). Collectively, these definitions demonstrate that the essential feature of homonymy lies in the sameness of the signifier and the difference of the signified.

The distinction between homonymy and polysemy constitutes one of the central issues in linguistic analysis. Although both phenomena involve a single formal structure associated with multiple meanings, the fundamental difference between them arises from the nature of the relationship among meanings. In polysemy, the different meanings of a word maintain a certain conceptual link, associative proximity, or historical continuity; in contrast, in homonymy, words that share the same sound or spelling have meanings that bear no semantic relationship to one another. For this reason, homonymy is regarded as an independent form of semantic differentiation separate from polysemy. As noted by Xanəliyeva, while polysemy involves meanings that share a common semantic feature, in homonymy this connection disappears entirely (Xanəliyeva, 2023, p. 282). Therefore, homonymy should be evaluated as a linguistic structure that demonstrates complete semantic divergence despite surface-level formal similarity.

In Turkish, the word *yaz* may refer both to the name of a season ("summer") and to the imperative form of the verb "to write," while the word *gül* may denote both a type of flower ("rose") and the imperative form of the verb "to laugh." These examples clearly illustrate homonymy. In such cases, although formal identity exists, there is no semantic relationship between the meanings. Consequently, homonymous words are typically listed under separate entries in dictionaries, since they do not represent different meanings of the same word but rather independent lexical units that coincidentally share the same form. Language users generally determine the intended meaning of such words through contextual cues.

It is known that various historical and structural factors play a role in the emergence of homonyms. Among these factors are the gradual convergence of originally different words into the same form as a result of historical sound changes, borrowings from foreign languages, and the separation of a polysemous word into independent meaning units after losing its original semantic unity over time (Xanəliyeva, 2023, p. 282). According to Aksan, homonymy may arise when two or more words that initially possess different meanings gradually come to resemble one another as a result of phonetic or morphological changes over time. In addition, the borrowing of a word from a foreign language that comes to share the same phonetic structure as an existing native word may also play a decisive role in the formation of homonymy (Aksan, 2016: 166). Ullmann addresses this formation process more systematically, identifying three principal factors: phonetic convergence, homonymic conflicts, and foreign language influence (Ullmann, 1970: 176–180). Furthermore, characteristics related to the writing system also play an important role in the development of homonymy. As noted by Aksan, especially in phonetic writing systems, the direct reflection of pronunciation in writing may cause originally different units to be written in the same form, thereby increasing instances of homonymy (Aksan, 2016: 93).

It should also be emphasized that the historical relationship between homonyms and polysemous words is not characterized by a simple one-directional opposition. In certain cases, the semantic connection between

the meanings of a polysemous word gradually weakens and eventually disappears, resulting in the formation of independent lexical units. In such situations, meanings that were originally part of the same lexical structure begin to function as separate words, leading to the emergence of homonymy. This process demonstrates that the relationship between polysemy and homonymy possesses a historical and dynamic character. Over time, these units that become homonyms may themselves undergo new semantic expansions and develop into independent polysemous structures. Thus, semantic relationships in language are not static but form a continuously evolving and interconnected system.

Xəlilov emphasizes that the fundamental criterion for identifying homonyms is not merely phonetic similarity but also the complete disappearance of any semantic connection between them. According to him, if no semantic relationship exists between two words sharing the same phonetic structure, they should be considered homonyms (Xəlilov, 2008: 163). This approach demonstrates that semantic separation, alongside formal similarity, is decisive in defining homonyms. In other words, the evaluation of homonymous words requires attention not only to their external forms but also to the independence of their semantic domains.

Ullmann's classification of homonymy is particularly significant in providing a systematic explanation of the different manifestations of this linguistic phenomenon. According to him, homonymy can be divided into three primary categories based on formal characteristics: **homophones**, **homographs**, and **complete homonyms** (Ullmann, 1978: 358). Homophones are words that share identical or very similar pronunciation but differ in spelling. Such units have the potential to create ambiguity particularly in spoken communication. Homographs, on the other hand, are words that share identical spelling but differ in pronunciation and meaning; these typically require greater attention in written language. Complete homonyms are words that are identical both in spelling and pronunciation but differ in meaning. This last group most clearly demonstrates the crucial role of context in semantic interpretation.

One of the fundamental characteristics of homonymy is the similarity in sound and spelling. Another essential feature is the absence of any semantic relationship between meanings. This element constitutes the most important criterion distinguishing homonymy from polysemy. A third defining feature is the central role of context in determining meaning. In order to identify which meaning of a formally identical word is intended, sentence-level and textual context must be carefully analyzed. Finally, homonymy is directly connected to the historical development of language; sound changes, borrowings, and orthographic variations over time contribute to its emergence. Therefore, homonymy should be regarded not only as a synchronic linguistic phenomenon but also as one with a diachronic dimension.

There are several reasons why homonyms do not become infinitely widespread within languages. The absence of semantic connections among meanings may make such words more difficult to learn and retain in memory. Additionally, when context is insufficiently clear during communication, homonyms may lead to misunderstanding. As noted by Xanəliyeva, although homonymy contributes to the diversification of expressive possibilities in language, it also carries the potential to complicate the clear transmission of meaning (Xanəliyeva, 2023, p. 282). Nevertheless, Abdullayev considers homonymy not merely as a structure that produces ambiguity but also as a system that prevents unnecessary lexical proliferation caused by accidental phonetic similarities and thereby contributes to linguistic economy (Abdullayev, 2013, p. 90). This perspective demonstrates that the function of homonyms in language is not limited to generating problems but also involves an economic and structural role in naming processes.

Homonymy functions as an important stylistic device not only in everyday communication but also in literary texts. Particularly in poetry, homonyms are used more intensively, and this usage often contributes to the formation of a rhetorical device known as *pun* (cinas). A pun is an aesthetic expressive technique created through the simultaneous use of words that share the same sound structure but possess different meanings. Hüseynzadə notes that homonyms are frequently preferred in poetic language, strengthening both semantic richness and phonetic harmony (Hüseynzadə, 1954, p. 15). However, when evaluating the stylistic functions of homonyms, it is also acknowledged that they are used more sparingly in literary texts compared to synonyms and antonyms. This is because the potential for semantic confusion requires more careful and controlled usage. Nevertheless, when employed appropriately within context, homonyms can add harmony, rhythm, density, surprise, and multilayered meaning to a text (Həsənov, 2003, p. 274).

In literary texts, the functions of homonymous words can generally be categorized under the headings of wordplay, humor and irony formation, the development of double meanings, and the creation of aesthetic depth. Wordplay formed through the deliberate juxtaposition of different meanings of the same word allows readers to perceive the text not only at a surface level but also within a multilayered interpretive field. Humor and irony are likewise often strengthened through unexpected semantic shifts and dual associations. The coexistence of different meanings of a word within the same context contributes both intellectual and aesthetic depth to the text. In this respect, homonymy should be regarded not only as a semantic feature but also as a poetic expressive tool in literary language.

However, transferring homonymy into the translation process is extremely difficult. This is because the semantic play created by two different words that share the same sound or spelling in the source language often cannot be reconstructed in the same way in the target language. This difficulty becomes even more evident in literary translations from German into Azerbaijani Turkish, since the phonological systems, orthographic conventions, vocabularies, and historical developments of the two languages differ significantly. Therefore, when homonymous structures in the source text cannot be reproduced directly in the target language, the translator must resort to various strategies.

One of the primary strategies is **explicitation**. Explicitation refers to expressing an implicit or dual meaning found in the source text in a clearer, more understandable, and interpretive manner in the target language. In structures containing homonymy, when it is not possible to preserve both meanings simultaneously, the translator may highlight one of them through an explanatory construction. This method is particularly functional in cases where accurate comprehension of meaning is the priority; however, excessive use of explicitation may weaken the aesthetic structure of the literary text, and therefore it should be applied carefully.

Another method is **adaptation**. In the adaptation strategy, the translator attempts to reconstruct the homonymous structure of the source text by using another wordplay or formal structure in the target language that produces a similar effect. The aim here is not to convey the exact lexical equivalent of the word but to preserve the effect created in the reader as much as possible. This method becomes particularly important in texts rich in humor, irony, and wordplay. Adaptation is a creative strategy that requires the translator to have a thorough understanding of the linguistic resources of both the source and target languages.

Compensation strategies are also frequently used in translating texts that contain homonymy. If the wordplay or double meaning present in the source text cannot be preserved in the same location in the target language, the translator may attempt to recreate this effect elsewhere in the text. In this way, an aesthetic or semantic function lost at one point can be compensated for in another, thereby preserving the overall balance of the text. This method is especially significant in literary translation, as it requires both flexibility and creativity.

Examples demonstrating how homonyms are resolved within context in translations from German into Azerbaijani Turkish clearly illustrate the practical dimension of this issue. The rendering of the phrase *"vom Balle"* in Goethe's text as *"Baldan evə qayıdarkən"* ("while returning home from the ball") is noteworthy (Goethe, 1958, p. 29; Qöte, 2010, p. 638). The German word *der Ball* exhibits a homonymous structure with meanings such as "ball" (object), "dance ball," and "point" (in games). In this instance, the translator did not rely solely on dictionary equivalents but instead selected the meaning required by the context, namely "ball" in the sense of a dance event. This example clearly demonstrates the decisive role of context in translating homonymous structures.

Similarly, the German word *der Sturm* represents a homonymous structure carrying meanings such as "storm," "tempest," and "assault." In examples taken from Remarque and Goethe, the translation equivalents of this word vary depending on context. In the sentence *"Tulpen und Narzissen – der pfirsichfarben und goldene Sturm des Frühlings"*, the word was not translated directly as "storm" or "tempest"; instead, a more interpretive and imagistic rendering, *"baharın narıncı, qızılı müjdəçiləri"* ("the orange and golden heralds of spring"), was preferred (Remarque, 1976, p. 18; Remark, 2009, p. 26). By contrast, in the example *"Wenn die Stürme des Berges kommen"*, the word was translated directly as *"tufan"* ("storm"), demonstrating a more direct equivalence (Goethe, 1958, p. 133; Qöte, 2010, p. 721). When these two examples are considered together, it becomes evident that in translating homonymous structures, the translator sometimes opts for contextual adaptation and at other times for direct equivalence.

Likewise, the examples involving *Strom* and *strömen* also highlight the importance of contextual interpretation in translating polysemous or homonymous structures. In the sentence *"Das kühle Wasser strömte über seine Haut"*, the verb *strömen* was not translated directly as "to flow," but instead rendered more freely and emotionally as *"bədənini qıdıqladı"* ("tickled his body") (Remarque, 1976, p. 23; Remark, 2009, p. 33). In contrast, the noun *Strom* was translated in different examples as *"sel"* ("flood") or *"coşmaq"* ("to surge"), depending on context (Goethe, 1958, pp. 133, 14; Qöte, 2010, pp. 721, 628). Such usages demonstrate that dictionary knowledge alone is insufficient in translating homonyms; without considering the atmosphere, style, and emotional tone of the text, accurate meaning transfer cannot be achieved.

Within this framework, homonymy in literary translation from German into Azerbaijani Turkish should be regarded not merely as a semantic problem but also as a field of aesthetic, cultural, and stylistic interpretation. When homonymous words are used in the source text to create wordplay, humor, irony, double meanings, and poetic intensity, their transfer into the target language may not be possible through direct dictionary equivalents alone. Therefore, the translator must develop creative solutions by taking into account context, cultural background, text type, and stylistic features. Strategies such as explicitation, adaptation, and compensation constitute the primary methods employed by translators in this process.

CONCLUSION

The conducted study has demonstrated that synonymy, polysemy, and homonymy constitute decisive semantic domains in establishing translation equivalence in literary translations from German into Azerbaijani Turkish. The analysis has shown that equivalence in literary translation cannot be achieved merely by finding dictionary equivalents for words in the target language. What is fundamentally important is the functional reconstruction of the source text's layers of meaning, stylistic features, emotional tone, aesthetic structure, and cultural connotations in the target language. In this respect, translation equivalence should not be regarded as a fixed and mechanical correspondence; rather, it represents a dynamic balance that is reshaped according to the context, genre, and communicative purpose of the text.

Evaluations conducted within the framework of synonymy have revealed that the translator's lexical choices influence not only semantic transfer but also the rhythm, emotional intensity, and stylistic orientation of the text. Examples related to polysemy have clearly demonstrated the decisive role of context in the translation process. Failure to correctly interpret the semantic layers of a word may result not only in semantic shifts but also in the disruption of the text's figurative and aesthetic texture. Homonymy, in particular, has emerged as one of the most challenging areas, espe-

cially in relation to wordplay, puns, and double-meaning structures, requiring the translator's creative intervention. Therefore, in literary translation, the translator should be regarded not merely as a transmitter seeking linguistic equivalents but also as an interpretive agent who reconstructs meaning, effect, and aesthetic form.

All these findings indicate that the direct and literal transfer of semantic structures between German and Azerbaijani Turkish is often not possible; instead, functional and aesthetic equivalence can be established through creative translation strategies. Consequently, successful literary translation should not be limited to grammatical accuracy alone; it must also convey the cultural horizon of the text, its narrative atmosphere, and the effect it produces on the reader into the target language. In this regard, the study demonstrates that synonymy, polysemy, and homonymy are not only subjects of linguistic analysis but also fundamental aesthetic and interpretive elements that determine the quality of literary translation.

Reference

1. Abdullayev, S. Ə. (2013). *Qeyri-səlis dilçilik təcrübəsi*. Victory.
2. Acar, Ö. (2010). Çokanlamlılık-eşadlılık ikileminde iştirâk-i lâfzî. *Ankara Üniversitesi İlahiyat Fakültesi Dergisi, 51*(2), 241–270.
3. Aksan, D. (2016). *Anlambilim: Anlambilimi konuları ve Türkçenin anlambilimi*. Bilgi Yayınevi.
4. Aktaş, Ş. (1986). *Edebiyatta üslûp ve problemleri*. Akçağ Yayınları.
5. Aliyeva, G. (2018). *Sinonimlərin tərcümə yolları (Natalia Ginzburg "Le voci della sera" əsəri əsasında)* [Yüksek lisans tezi, Azərbaycan Dillər Universiteti].
6. Babayev, A. M. (2001). *Müasir Azərbaycan dilinin funksional üslubları*. İşıq.
7. Bıçkıcı, T. (2016). *Edebiyat çevirisinde çeviri kuramları üzerinden çevirmenin rolü* [Yüksek lisans tezi, Sakarya Üniversitesi Sosyal Bilimler Enstitüsü].
8. Bilgin, M. (2002). *Anlamdan anlatıma Türkçemiz*. Kültür Bakanlığı Yayınları.
9. Bussmann, H. (1998). *Routledge dictionary of language and linguistics*. Routledge.
10. Catford, J. C. (1965). *A linguistic theory of translation*. Oxford University Press.
11. Cəfərov, S. (1982). *Müasir Azərbaycan dili*. Maarif.
12. Cruse, D. A. (1987). *Lexical semantics*. Cambridge University Press.
13. Dəmirçizadə, Ə. M. (1962). *Azərbaycan dilinin üslubiyyatı*. Azərtədrisnəşr.
14. Eco, U. (2012). Hemen hemen aynı şeyi söylemek (S. Rifat, Çev.). In M. Rifat (Ed.), *Çeviri(bilim) nedir? Çeviri seçkisi II* (ss. 173–176). Sel Yayıncılık.
15. Əfəndiyeva, T. Ə. (1980). *Azərbaycan dilinin leksik üslubiyyatı*. Elm.
16. Filizok, R. (2001). *Anlam analizine giriş*. Ege Üniversitesi Edebiyat Fakültesi Yayınları.
17. Goethe, J. W. (1958). *Die Leiden des jungen Werthers*. Fremdsprachige Literatur.
18. Gudykunst, W. B., Ting-Toomey, S., & Nishida, T. (1996). *Communication in personal relationships across cultures*. Sage Publications.
19. Günay, D. (2007). *Sözcük bilimine giriş*. Multilingual.
20. Gürlek, M. (2016). Çokanlamlı sözlükbirimler üzerine bir değerlendirme. *Dicle Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 8*(17), 172–180.
21. Hartmann, R., & James, G. (1998). *Dictionary of lexicography*. Routledge.
22. Həsənov, H. Ə. (1990). *Müasir Azərbaycan dilinin leksikası*. Maarif.
23. Həsənov, H. Ə. (2001). *Müasir Azərbaycan dilinin leksikası*. Bakı Universiteti.
24. Həsənov, H. Ə. (2003). *Nitq mədəniyyəti və üslubiyyatın əsasları*. Bakı Universiteti.
25. Hüseynzadə, M. H. (1954). *Müasir Azərbaycan dili: Leksika, fonetika, morfologiya*. ADU nəşriyyatı.
26. İsmayılova, R. (2022). *Çoxmənalı sözlərin kontekstual mənaları və onların dilin lüğət tərkibini zənginləşdirməsi* [Magistr dissertasiyası, Azərbaycan Dillər Universiteti].
27. Jakobson, R. (1959). On linguistic aspects of translation. In R. A. Brower (Ed.), *On translation* (pp. 232–239). Harvard University Press.
28. Kafka, F. (1983). *Das erzählerische Werk*. Rütten & Loening.
29. Kafka, F. (2010). *Seçilmiş əsərləri* (Ç. Qurbanlı, V. Hacıyev, & Y. Savalan, Tərc.). Şərq-Qərb.
30. Kahraman, S. (2015). *Dilde çok anlamlılık ve belirsizlik* [Yüksek lisans tezi, Dokuz Eylül Üniversitesi Sosyal Bilimler Enstitüsü].
31. Lakoff, G., & Johnson, M. (2010). *Metaforlar: Hayat, anlam ve dil* (G. Y. Demir, Çev.). Paradigma Yayınları.
32. Lipka, L. (2002). *English lexicology: Lexical structure, word semantics, and word-formation*. Narr.
33. Löbner, S. (2003). *Semantik*. Walter de Gruyter.
34. Lyons, J. (1983). *Kuramsal dilbilime giriş* (A. Kocaman, Çev.). Türk Dil Kurumu Yayınları.
35. Lyons, J. (1995). *Linguistic semantics: An introduction*. Cambridge University Press.
36. Murphy, M. L. (2003). *Semantic relations and the lexicon*. Cambridge University Press.
37. Newmark, P. (1988). *A textbook of translation*. Pergamon Press.
38. Nida, E. A. (1945). Linguistics and ethnology in translation problems. *Word, 2*, 194–208.
39. Nida, E. A., & Taber, C. R. (1982). *The theory and practice of translation* (2nd ed.). E. J. Brill.
40. Persson, G. (1990). *Meanings, models and metaphors: A study in lexical semantics in English*. Almqvist & Wiksell International.
41. Qöte, Y. V. (2010). *Seçilmiş əsərləri* (Ç. Qurbanlı, Tərc.). Şərq-Qərb.
42. Qurbanov, A. (2019). *Müasir Azərbaycan ədəbi dili*. Azərbaycan Milli Elmlər Akademiyası
43. Qurbanov, A. M. (1985). *Müasir Azərbaycan ədəbi dili*. Maarif.
44. Remark, E. M. (2009). *Seçilmiş əsərləri* (Ç. Qurbanlı & V. Hacıyev, Tərc.). Şərq-Qərb.

45. Remarque, E. M. (1976). *Die Nacht von Lissabon*. Aufbau-Verlag.

46. Ricoeur, P. (2003). *The rule of metaphor: The creation of meaning in language*. Routledge.

47. Riemer, N. (2010). *Introducing semantics*. Cambridge University Press.

48. Riesel, E. (1954). *Abriß der deutschen Stilistik*. Hochschule.

49. Svayq, Ş. (2010). *Seçilmiş əsərləri* (Ç. Qurbanlı, V. Hacıyev, Y. Savalan, Z. Məmmədov, H. Arzulu, & A. Nəbi, Tərc.). Şərq-Qərb.

50. Toklu, O. (2003). *Dilbilime giriş*. Akçağ Yayınları.

51. Ullmann, S. (1970). *Semantics: An introduction to the science of meaning*. Alden Press.

52. Ullmann, S. (1972). *Semantics: An introduction to the science of meaning*. Basil Blackwell.

53. Vardar, B., vd. (1998). *Açıklamalı dilbilim terimleri sözlüğü*. Multilingual.

54. Verdiyeva, Z. N., Ağayeva, F. M., & Adilov, M. İ. (1979). *Azərbaycan dilinin semasologiyası*. Maarif.

55. Veysəlli, F. Y. (2013). *Dilçiliyin əsasları*. Mütərcim.

56. Xanəliyeva, İ. (2023). Çoxmənalılığın inkişafını şərtləndirən amillər. *AMEA Filologiya və sənətşünaslıq, 1*, 279–283.

57. Xəlilov, B. Ə. (2008). *Müasir Azərbaycan dilinin leksikologiyası*. Nurlan.

58. Yazıcı, M. (2005). *Çeviribilimin temel kavram ve kuramları*. Multilingual.

59. Zweig, S. (1986). *Triumph und Tragik des Erasmus von Rotterdam*. Der Morgen.

TECHNICAL SCIENCES

IMPLEMENTATION OF A SECURITY MECHANISM IN MICROSERVICES ARCHITECTURE

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Abstract
Microservices architecture has become an essential part of modern engineering and provides the basis for building scalable and responsive systems. This decentralized architecture enables smooth communication between the various systems and devices, but also poses significant security challenges. This study examines centralized identity and access management (IAM) to address modern security threats. The study aims to help developers respond to the challenges of decentralized security by implementing technical solutions such as Keycloak and standard authentication protocols such as OAuth2.0 and JWT. The results show that the centralized security layer reduces system failures and interruptions, which leads to increased efficiency in providing the necessary services.
Keywords: Microservices, Keycloak, IAM, OAuth2.0, JWT, API security.

Introduction. Microservices architecture has become the cornerstone of modern engineering and enables organizations to build highly scalable, flexible and resilient systems. Unlike traditional monolithic applications, microservices break down large software applications into smaller, self-contained services that communicate with each other over APIs. This decentralized structure offers a number of advantages, including greater scalability, faster development cycles and easier maintenance. However, the very nature of microservices - distributed, networked and loosely linked - also poses major security challenges. Each microservice often uses sensitive data such as user credentials, financial information or personal identifiers, and the proliferation of API endpoints increases the scope for cybercriminals to attack. Common threats against microservices include malware, phishing, token theft, abuse of APIs, and attempts to gain access through an unauthenticated network connection [1].

The security of microservices is substantially more complex than that of monolithic applications due to several factors:

1. **Distributed Data and Services:** Sensitive information is distributed across multiple services and databases, making it difficult to enforce consistent access control.
2. **Multiple Communication Channels:** Microservices rely heavily on APIs and network communications, which, if not properly secured, may be exploitable by attackers.
3. **Heterogeneous Technology Stack:** Different services can use different programming languages, frameworks and databases, which makes it difficult to implement a single security policy.
4. **Dynamic Scaling and Deployment:** Services are often deployed, updated, and scaled up dynamically, which poses challenges for traditional verification and monitoring mechanisms.

Identity and Access Management (IAM) is a key strategy for addressing these problems. By centralizing authentication and authorization, IAM ensures that sensitive resources can only be accessed by authorized users and services, while providing audit, logging and compliance mechanisms. Among the available IAM solutions, Keycloak has become the widely adopted open source platform for securing modern applications. It supports industry standard protocols such as OAuth2.0, OpenID Connect, and JWT, and allows developers to implement single sign-on (SSO), token authentication, and granular access control for distributed services [2].

The aim of this research is to provide a comprehensive understanding of centralized IAM and to explore practical solutions to ensure the provision of microservices in the real world. By embedding Keycloak in the microservice architecture, this study aims to demonstrate how the centralized layer of security can reduce the risk of unauthorized access, simplify identity management and increase operational efficiency. In addition, the research assesses how automation of authentication and token validation can reduce system failures, minimize human error and increase the overall reliability of distributed systems. The aim of this work is ultimately to provide developers, system architects and organizations with actionable guidance to build secure, resilient and manageable microservices applications.

Experimental part

The research involves establishing a centralized authentication strategy using the Keycloak platform. The experimental setup follows a specific logic where the API Gateway acts as the central intelligence of the security layer.

The working principle of the proposed system is as follows:

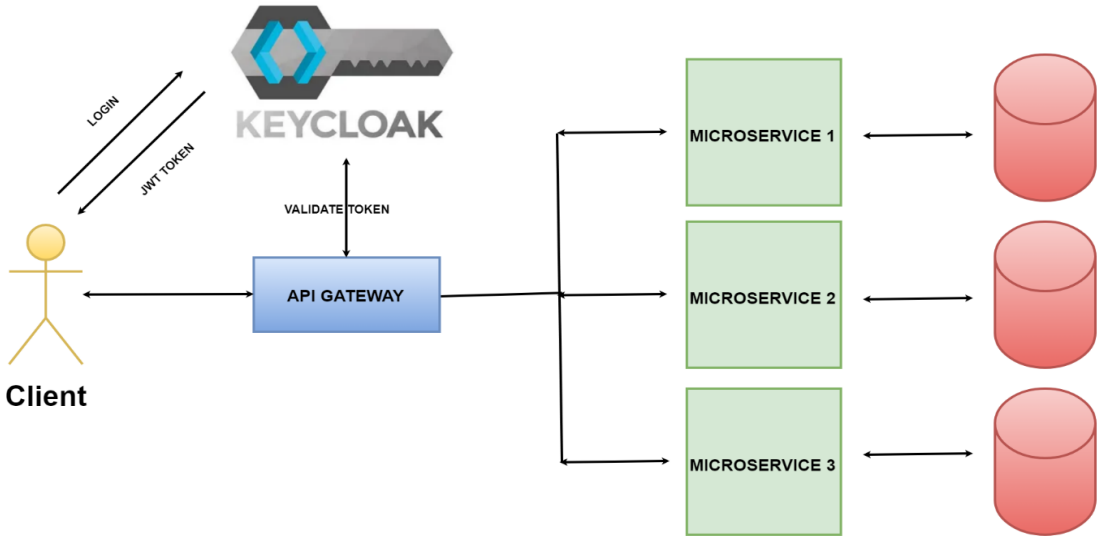


Figure 1: Implementation of Keycloak-based Security Flow in Microservices

- **Authentication:** The Client initiates a Login request directly to the Keycloak server. This may be done y the web interface or by program [3].

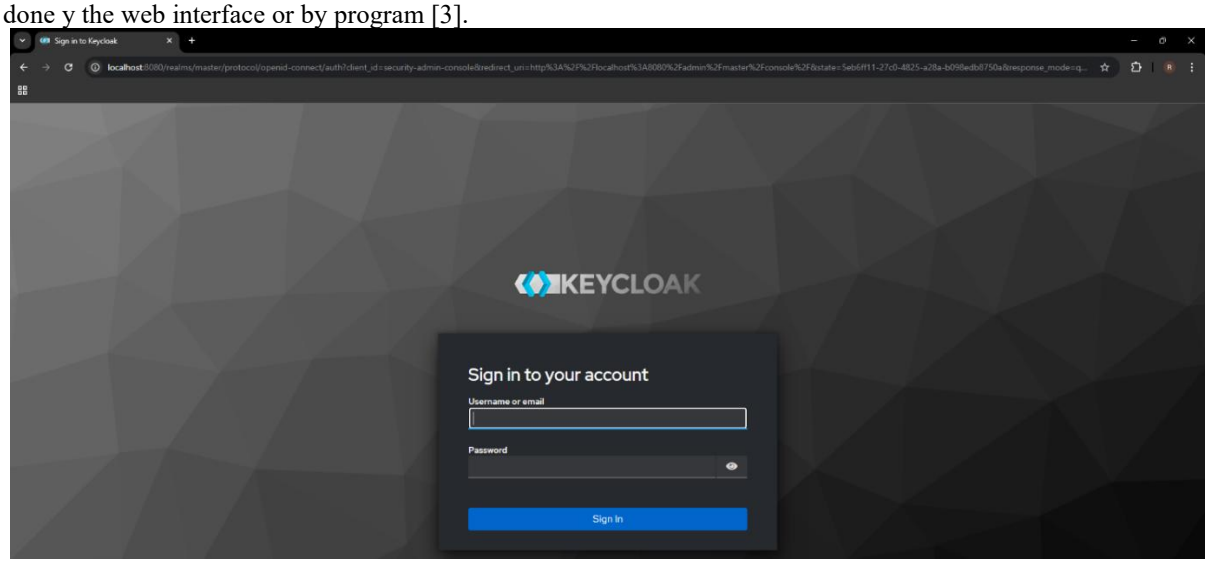


Figure 2. Keycloak Sign-in Interface

We send credentials such as username, password, and client_secret via Postman to the token endpoint to receive an authorization token.

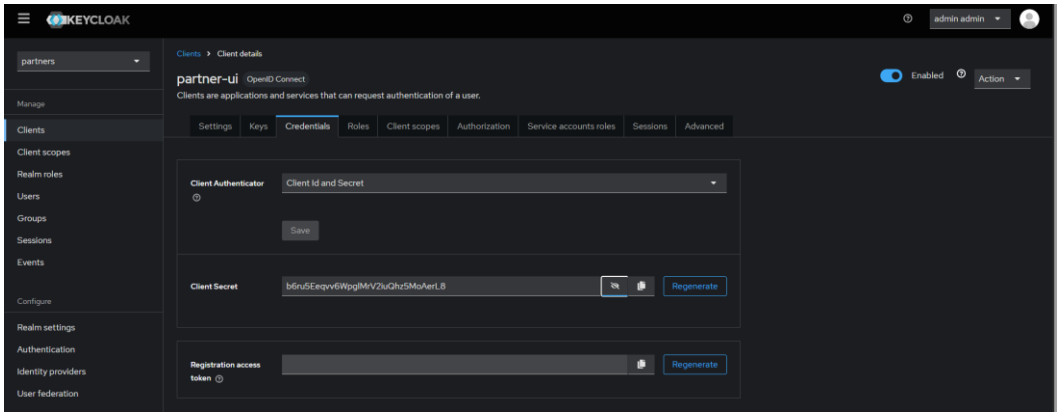
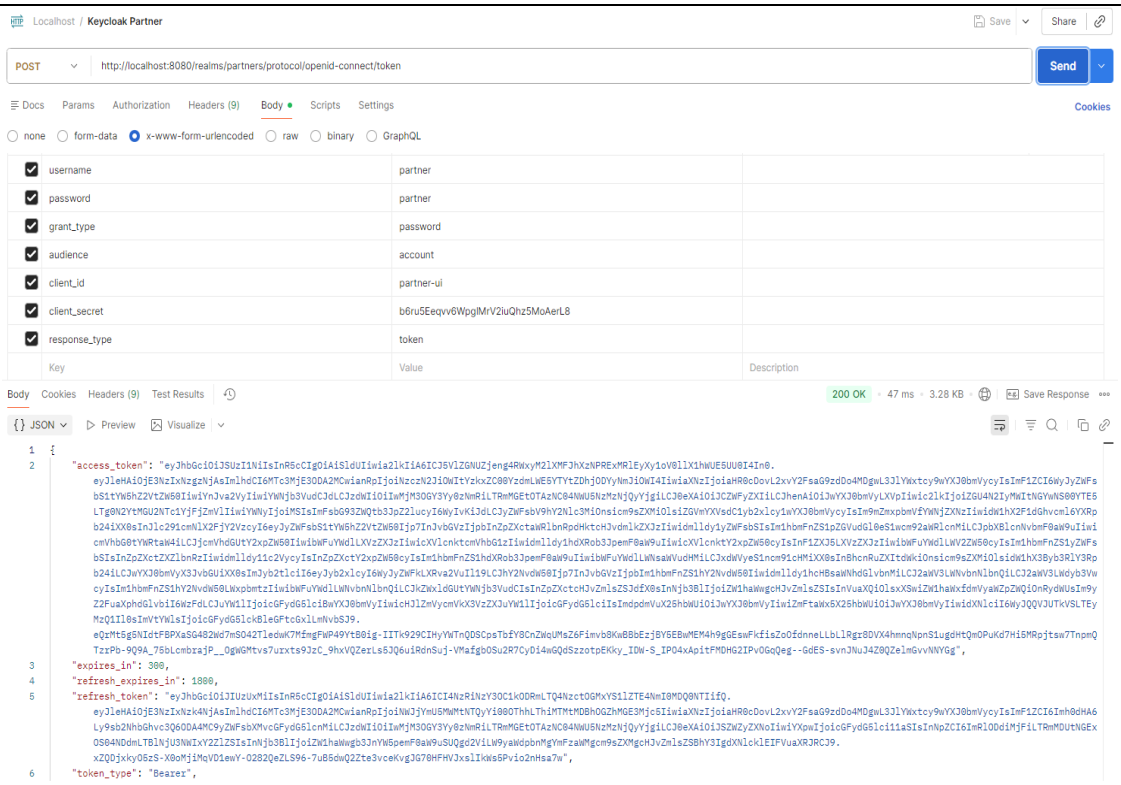


Figure 3. Keycloak Sign-in Interface


Localhost / Keycloak Partner
Save
Share
POST
http://localhost:8080/realms/partners/protocol/openid-connect/token
Send
Docs
Params
Authorization
Headers (9)
Body
Scripts
Settings
Cookies
none
form-data
x-www-form-urlencoded
raw
binary
GraphQL
username
partner
password
partner
grant_type
password
audience
account
client_id
partner-ui
client_secret
b6ru5Eeqvv6WpgIMrV2iuQhz5MoAerL8
response_type
token
Key
Value
Description
Body
Cookies
Headers (9)
Test Results
200 OK
47 ms
3.28 KB
Save Response
JSON
Preview
Visualize
{
"access_token": "eyJhbGciOiJSUzI1NiIsInR5cCIgOiAiSldUIiwia2lkIiA6ICJ5VlZGNUZjeng4RWxyM2lXMFJhXzNPRExMRlEyXy1oV0llX1hWUE5UU0I4In0.
eyJleHAiOjE3NzIxNzgzNjAsImlhdCI6MTc3MjE3ODA2MCwianRpIjoiNzczN2JiOWItYzkxZC00YzdmLWE6YTYtZDhjODYyNmJiOWI4IiwiaXNzIjoiaHR0cDovL2xvY2FsaG9zdDo4MDgwL3JlYWxtcy9wYXJ0bmVycyIsImF1ZCI6WyJyZWFs
bS1tYW5hZ2VtZW50IiwiYnJva2VyIiwiYWNjb3VudCJdLCJzdWIiOiIwMjM3OGY3Yy0zNmRiLTRmMGEtOTAzNC04NWU5NzMzNjQyYjgiLCJ0eXAiOiJCZWFyZXIiLCJhenAiOiJwYXJ0bmVyLXVpIiwic2lkIjoiZGU4N2IyMWItNGYwNS00YTE5
LTg0N2YtMGU2NTc1YjFjZmVlIiwiYWNyIjoiMSIsImFsbG93ZWQtb3JpZ2lucyI6WyIvKiJdLCJyZWFsbV9hY2Nlc3MiOnsicm9sZXMiOlsiZGVmYXVsdC1yb2xlcy1wYXJ0bmVycyIsIm9mZmxpbmVfYWNjZXNzIiwidW1hX2F1dGhvcml6YXRp
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cmVhbG0tYWRtaW4iLCJjcmVhdGUtY2xpZW50IiwibWFuYWdlLXVzZXJzIiwicXVlcnktcmVhbG1zIiwidmlldy1hdXRob3JpemF0aW9uIiwicXVlcnktY2xpZW50cyIsInF1ZXJ5LXVzZXJzIiwibWFuYWdlLW2ZW60cyIsIm1hbmFnZS1yZWFsbS1tYW5hZ2VtZW50IiwibWFuYWdlLWNsaWVudHMiLCJxdWVyeS1ncm91cHMiXX0sInBhcnRuZXItdWkiOnsicm9sZXMiOlsiZGVmYXVsdC1yb2xlcy1wYXJ0bmVycyIsIm1hbmFnZS1hY2NvdW50Iiwidmlldy1wcm9maWxlIl19LCJwYXJ0bmVycy1yZWFsbS1tYW5hZ2VtZW50Ijp7InJvbGVzIjpbIm1hbmFnZS1hY2NvdW50Iiwidmlldy1wcm9maWxlIl19fSwic2NvcGUiOiJwYXJ0bmVyLXVpIHJvbGVzIHByb2ZpbGUgZW1haWwiLCJjcmVhdGUtY2xpZW50cyIsInVtYV9hdXRob3JpemF0aW9uIiwicXVlcnktcmVhbG1zIiwidmlldy1hdXRob3JpemF0aW9uIiwicXVlcnktY2xpZW50cyIsInF1ZXJ5LXVzZXJzIiwibWFuYWdlLW2ZW60cyIsIm1hbmFnZS1yZWFsbS1tYW5hZ2VtZW50IiwibWFuYWdlLWNsaWVudHMiLCJxdWVyeS1ncm91cHMiXX0sInBhcnRuZXIt

number of concurrent users increases, the central authentication mechanism maintains a consistent response time thanks to stateless JWT authentication and optimized caching strategies [5]. Compared to a decentralized authentication model, where each service independently validates credentials, a centralized model reduces the number of cryptographic operations and reduces network overhead between services.

The coverage of security cases has been significantly extended beyond basic authentication. The system in place implements advanced password policies that are in line with modern security standards.

- Password history enforcement prevents users from reusing their previous passwords. For example, if the policy stores the last 10 passwords, the user cannot reuse any of those 10 previously defined credentials.
- Complexity requirements ensure passwords contain a combination of uppercase and lowercase letters, numeric digits, and special characters [4].
- Minimum length constraints and expiration policies further strengthen protection [4].
- Account lockout mechanisms limit brute-force attempts after repeated failed login trials.

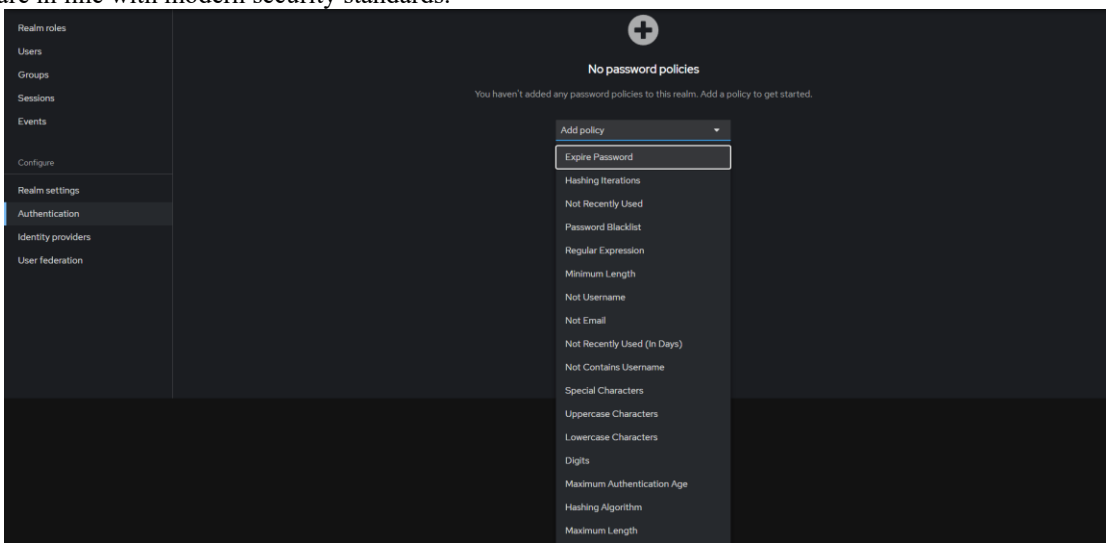

Figure 6. Password Policy Configuration Interface in Keycloak Admin Console

These controls significantly reduce the risks associated with credential re-use, brute force attacks, and unauthorized access attempts. In simulated abuse scenarios, such as repeated logon failures or attempts to reuse passwords, the system consistently blocked non-compliant actions, demonstrating strong enforcement of the security rules.

Moreover, centralization improves the behavior of the system during partial failures. If the individual microservice is not available, authentication and authorization services will remain unaffected, as they are isolated and deployed independently. This architectural separation increases fault tolerance and ensures that safety mechanisms remain operational even after the service has ceased to function. Observation has confirmed that the token expiration and replacement mechanisms continue to function properly under stress and failure simulations, which prevents session hijacking and unlimited token abuse.

Another important result is improved auditability. As all identity-related transactions go through a central IAM provider, the system maintains consolidated login attempts, token issuance, password changes, and access decisions. This single audit trail enhances compliance readiness and facilitates incident response procedures.

Overall, the results show that the Keycloak-integrated architecture not only improves endpoint protection, but also creates a scalable, scalable, maintainable and policy-driven security ecosystem that is suitable for enterprise and e-government systems.

Recommendations and Future Work

The following strategic and technical recommendations are proposed to further strengthen and develop the security position of microservice systems:

1. Full centralization of security management

Re-architect the environment to rely exclusively on a single centralised IAM program for authentication, authorization, and policy enforcement for all microservices. This approach avoids duplicate security configurations across services and ensures consistent application of the policy. Future improvements may include dynamic updates of policies without requiring a service move.

2. Standardization of single sign-on (SSO)Adopt single sign-on as a compulsory standard for business and e-government platforms. SSO improves the user experience by allowing seamless access to multiple services using a single authentication session, while at the same time maintaining high security through authentication by means of tokens. The integration of SSO with role-based and attribute-based access control mechanisms can provide granular authorization without compromising usability.

3. Automated Security Validation and Policy Enforcement

Automatically validate security configurations through CI and CD channels. Automated checks may verify the password policy, token lifetime, role mapping, and endpoint protection rules prior to deployment. This reduces human configuration errors,

minimizes system failures, and improves reliability of service provision.

4. Enhanced Monitoring and Observability

Integrate advanced monitoring tools for continuous monitoring of authentication latency, token validation times, login failure patterns and suspicious activity trends. The combination of centralized logging and real-time alert systems will enhance proactive threat detection and incident response capabilities.

5. Multi-Factor Authentication (MFA) Expansion

Extend the system with mandatory multi-factor authentication to sensitive services. Future work may include biometric authentication or hardware-based encryption for high risk operations.

6. Adaptive and Risk-Based Authentication

Future research may explore AI-driven adaptive authentication mechanisms. By analyzing behavioral patterns (e.g., unusual login location or device change), the system could dynamically increase authentication requirements when risk levels rise.

References

1. J. Arafat, F. Tasmin, and S. Poudel, "Next-generation event-driven architectures: Performance, scalability, and intelligent orchestration across messaging frameworks," arXiv preprint arXiv:2510.04404, 2025. [Online]. Available: https://arxiv.org/abs/2510.04404

2. Keycloak, Keycloak Documentation. [Online]. Available: https://www.keycloak.org/documentation. Accessed: 2026.

3. Keycloak, Keycloak Server Administration Guide. [Online]. Available: https://www.keycloak.org/docs/latest/server_admin/index.html. Accessed: 2026.

4. Tufin, *Keycloak Password Policy Overview*. [Online]. Available: https://forum.tufin.com/support/kc/latest/Content/Suite/PasswordPolicy.htm. Accessed: 2026.

5. Keycloak, *JWT Authorization Grant*. [Online]. Available: https://www.keycloak.org/securing-apps/jwt-authorization-grant. Accessed: 2026.

POSSIBILITIES OF DEVELOPING THE TECHNOLOGY OF A FUNCTIONAL ENERGY DRINK BASED ON PECTIN

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Abstract
Currently, the increase in the consumption of energy drinks makes the issue of their safety for the human body urgent, meaning that the long-term use of drinks with synthetic caffeine, taurine, and artificial additives can have a negative effect on the body. In this regard, the development of a safe and functional drink based on natural components is an important scientific direction. The purpose of the research work is to substantiate the possibility of developing a functional product based on apple pectin and plant extracts that has a tonic effect alternative to synthetic energy drinks and high antioxidant activity.
Keywords: pectin, functional drink, apple pectin, plant extract, antioxidant, food technology.

The increasing level of energy drink consumption in the modern food industry has brought the issue of their safety to the agenda. In particular, there is growing scientific evidence that the long-term effects of products rich in artificial stimulators and chemical additives negatively affect the cardiovascular system, nervous system, and metabolism. In such a situation, the direction of developing functional drinks based on natural raw materials is of scientific and industrial interest.

In food technology, plant polysaccharides, especially pectin, are considered natural structuring agents and biologically active components. One of the widely distributed sources of pectin is the apple, which makes it a technologically accessible and safe ingredient. In addition, the use of plant extracts makes it possible to create products that provide a natural energy effect, which forms the basis of scientific research aimed at reducing dependence on synthetic analogs.

In the work of Muzyka M.Yu., which considered the prospects for creating functional drinks, the structural and physiological advantages of pectin were comprehensively analyzed. The author notes that in improving the quality of functional drinks, pectin plays an important role not only as a viscosity former but also as a biologically active component. The study shows that products with added pectin have a high ability to bind toxins in the body, and the conclusion is given that "pectin-based drinks occupy a special place in the functional food segment through their detoxification effect" [1, 2].

Adygezalova S.G., who studied the nutritional value of drinks with added pectin, proves the technological advantages of functional pectin-containing products with actual experimental data. The author notes that pectin, along with stabilizing the structure of the drink, has a mild effect on the gastrointestinal tract. As a result of the research, it was concluded that "the use of pectin as a natural hydrocolloid not only improves the texture of the drink but also increases its biological value" [3, 4].

Pectins are linear colloids with a molecular length of approximately 10^{-4} mm and a molecular weight from 50,000 to 200,000. The main structural component of pectin is D-galacturonic acid (containing up to 55%), which determines its functional properties. In addition to galacturonic acid, pectin contains other organic compounds, including neutral sugars and methoxyl groups. As a result of the biochemical analysis of apple raw materials, the mass fraction of pectic substances in its composition was determined (Table 1).

Table 1

Biochemical composition of raw materials

Raw material	Mass fraction of pectic substances, %	Mass fraction of soluble pectin, %
Apple	**1.31**	**0.35**

This statement shows that in the creation of a natural energy product, pectin is effective not only functionally but also technologically. Natural drinks enriched with pectin can be in high demand among functional foods. Because the compatibility of pectin in the composition of fruit-based drinks has been considered in studies conducted by scientists. That is, by adding pectin to fruit juices, it is possible to increase the storage stability and nutritional value of the product [5, 115].

Also, scientists have noted in their works that the ability of pectin to bind heavy metals and toxins increases the special adsorption activity properties of drinks containing pectin and helps to eliminate toxic compounds from the body [6, 69]. This scientific concept allows for justifying the safety advantage of pectin-based energy products, since synthetic energetics do not have such a protective effect.

Summarizing the literature data, the potential of pectin in the production of functional foods is explained by its multifaceted biological effects. Although the presence of high doses of caffeine and chemical stimulants in the composition of synthetic energy drinks provides short-term alertness, it can pose a long-term threat to health. And the use of pectin in drinks based on nat-

ural ingredients optimizes the viscosity of the drink, increases its sensory quality, has a mild effect on the body, and has additional protective properties. In addition, the gel-forming ability of pectin provides the structural stability of the product and improves the rheological properties of drinks [5, 28].

During the study, apple pectin (high-methoxyl) is used as the main structure-forming component. As a result of the analysis of scientific data, it was determined that pectin stabilizes the structure of the drink and optimizes its viscosity, and its adsorption and prebiotic properties increase the functional value of the product. And in order to increase biological activity, rosehip and green tea extracts are introduced. Rosehip extract enriches with vitamin C, and green tea catechins provide antioxidant activity. The combination of pectin and plant extracts makes it possible to develop a functional drink with a tonic effect without synthetic stimulants.

A comparative evaluation of the antioxidant activity of apple pectin and green tea extract was carried out using the method of neutralizing DPPH radicals (Table 2).

Table 2

Antioxidant activity of apple pectin and green tea extract according to the DPPH method

№	Sample	Concentration, %	DPPH inhibition level, %	IC_{50}, mg/ml
1	Apple pectin	0.5	52.6 ± 1.4	0.47
2	Apple pectin	1.0	74.2 ± 1.9	-
3	Green tea extract	0.5	68.9 ± 1.2	0.32
4	Green tea extract	1.0	88.5 ± 1.5	-

The research results show that as the pectin concentration increases, the antioxidant activity increases. Although the antioxidant activity of green tea extract is high, apple pectin also shows a pronounced antioxidant effect. The IC_{50} indicator was determined at the level of 0.47 mg/ml, which proves that the ability of apple pectin to neutralize free radicals is moderately pronounced. The low IC_{50} value indicates the high ability of green tea to neutralize radicals. However, the combination of pectin with its structure-forming and prebiotic properties creates a complex biological effect in the composition of a functional drink. The obtained results show that pectin can serve as a basis for use in a functional drink not only as a structure-forming component but also as a biologically active ingredient [7].

Thus, the combined use of pectin and green tea extract allows achieving a synergistic antioxidant effect and strengthens the scientific basis for developing a natural alternative to synthetic energy drinks.

References

1. Muzyka M.Yu. Analysis of the prospects for creating functional drinks using pectin // Food industry. – 2020. – No. 3. – P. 45–52. URL: https://cyberleninka.ru/article/n/analiz-perspektiv-sozdaniya-funktsionalnyh-napitkov-s-ispolzovaniem-pektina

2. Mironova S.V., Kirillova O.V. Obtaining and using pectic substances from plant raw materials // Food industry. – 2018. – No. 3. – P. 22–27.

3. Adygezalova S.G. Functional pectin-containing drinks based on tomato juice // Biotechnology and industry. – 2021. – No. 4. – P. 78–85. URL: https://cyberleninka.ru/article/n/funktsionalnye-pektinsoderzhaschie-napitki-na-osnove-tomatnogo-soka

4. Solovyeva I.A., Shemetova L.A. Pectins and their use in the food industry: textbook. – M.: KolosS, 2015. – 208 p.

5. Alibaeva B.N. Development of functional drinks based on fruit juices with the addition of pectin // International Conference on Technology Development. – 2018. – P. 112–118. URL: https://internationalconference.ru/images/PDF/2018/41/technology-development.pdf

6. Tikhonova I.L. Study of the adsorption capacity of functional pectin-containing drinks // Nutrition issues. – 2024. – Vol. 93, No. 2. – P. 66–73. URL: https://journals.eco-vector.com/0869-7698/article/download/676102/191437

7. Kukin M.Yu. The influence of pectin on the physicochemical properties of functional drinks // Technology of food production. – 2018. – No. 2. – P. 25–31. URL: https://pdfs.semanticscholar.org/979c/075568956419a1402d8f742d27eddcf3c5e6.pdf

ANALYSIS AND PERFORMANCE EVALUATION OF PUBLIC LoRaWAN NETWORK COVERAGE IN URBAN ENVIRONMENTS

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Abstract

This study presents an analysis and performance evaluation of a public LoRaWAN network deployed in the urban environment of Köthen, Germany. The research focuses on assessing network coverage and communication reliability under real outdoor conditions using different radio transmission parameters. An end device based on an Arduino Mega 2560 and a Dragino LoRa GPS Shield was configured and connected to The Things Stack (TTS) to transmit georeferenced test packets from multiple measurement points across the city. The experimental evaluation considered key communication metrics, including Received Signal Strength Indicator (RSSI), Signal-to-Noise Ratio (SNR), and Packet Delivery Rate (PDR), for several spreading factors from SF7 to SF12 and different transmission power levels. Based on the collected data, coverage heatmaps were generated to visualize the spatial distribution of signal quality and identify stable, weak, and marginal reception zones. The results show that higher spreading factors significantly improve coverage and delivery reliability, while lower transmission power reduces network performance, especially in obstructed urban areas. The findings provide practical insights into the optimization of public LPWAN deployments and can support future planning of LoRaWAN infrastructure in urban environments.

Keywords: LoRaWAN, LPWAN, urban coverage, RSSI, SNR, packet delivery rate, The Things Stack, IoT.

Introduction

The rapid development of the Internet of Things (IoT) has created a growing demand for wireless communication technologies capable of supporting large numbers of low-power devices over wide geographic areas. In many modern smart city, industrial, agricultural, and environmental monitoring applications, conventional short-range wireless technologies such as Wi-Fi or Bluetooth are not suitable due to their limited communication distance and relatively high energy consumption. At the same time, cellular solutions may provide wide coverage, but they are often associated with higher infrastructure costs and increased power requirements. For this reason, Low Power Wide Area Network (LPWAN) technologies have become an important area of research and practical implementation.

One of the most important configurable parameters in LoRaWAN is the Spreading Factor (SF), which determines the trade-off between communication range, data rate, transmission time, and receiver sensitivity. Higher spreading factors generally improve signal detectability and increase achievable range, but they also increase time-on-air and reduce transmission efficiency. In addition, transmission power has a direct influence on the strength and reliability of the uplink signal, especially in areas with partial obstruction or weak line-of-sight conditions. For this reason, the combined analysis of spreading factor and transmission power is essential for optimizing LoRaWAN performance in practical deployments.

This study focuses on the analysis and performance evaluation of a public LoRaWAN network in the city of Köthen, Germany. The objective of the research is to investigate how different radio transmission parameters influence signal quality, communication reliability, and spatial coverage under real outdoor urban conditions. For this purpose, an end device based on an Arduino Mega 2560 and a Dragino LoRa GPS Shield was configured to transmit georeferenced test messages through a public gateway connected to The Things Stack network server. Measurements were carried out at multiple locations across the city, and the received packets were analyzed using key performance indicators such as Received Signal Strength Indicator (RSSI), Signal-to-Noise Ratio (SNR), and Packet Delivery Rate (PDR).

The practical significance of this work lies in its contribution to the planning and optimization of public LoRaWAN infrastructure. By visualizing the collected data in the form of coverage heatmaps and comparing the results for different transmission settings, it becomes possible to identify areas of strong and weak reception, determine the most effective communication modes, and evaluate the limitations of the current deployment.

First, the hardware platform, network setup, and onboarding process are described. Then, the methodology of data transmission and field measurements is presented. After that, the collected data are analyzed through heatmaps and communication metrics. Finally, the main results are

discussed and recommendations for improving LoRaWAN coverage in urban areas are provided.

2 The experimental part

2.1 Device configuration and network onboarding

The experimental study was carried out in the city of Köthen, Germany, to evaluate the performance of a public LoRaWAN network under real urban outdoor conditions. A Kerlink Wirnet Station gateway was used as the network infrastructure element. The gateway operated in the EU863–870 MHz frequency band and was configured according to EU868 regional parameters.

As an end device, an Arduino Mega 2560 equipped with a Dragino LoRa/GPS Shield was used. This hardware platform enabled both LoRaWAN communication and GPS-based location tracking during field measurements. The LoRa transceiver was connected to the Arduino Mega through the SPI interface, while additional control and interrupt pins were assigned for proper radio operation. The GPS module was used to obtain the coordinates of each measurement point. The pin mapping between the Arduino Mega 2560, the Dragino shield, and the LoRa module is shown in Fig. 1.

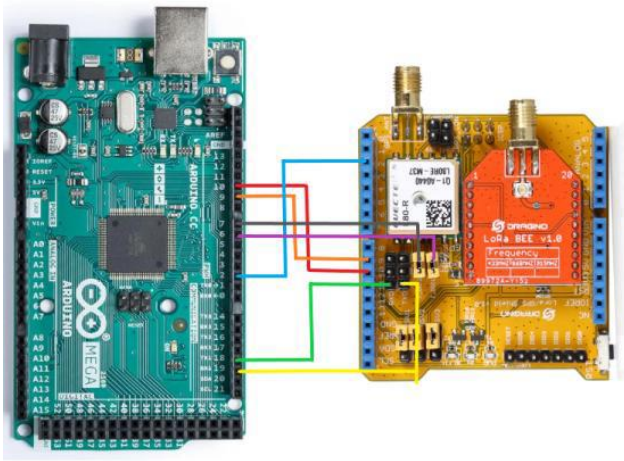

Fig. 1. The pin mapping between the Arduino Mega 2560 and Dragino shield

Table 1.

Pin mappind between Arduino Mega 2560, Dragino Shield v1.3 and LoRa BEE v1.1

Interface	Arduino Mega 2560	LoRa Bee v1.1	Quectel L80 (GPS module)	Description
SPI	D51	MOSI	-	Data from Mega to Radio
SPI	D50	MISO	-	Data from Radio to Mega
SPI	D52	SCK	-	Timing/Clock Signal
SPI	D10	NSS	-	Chip Select (Radio On/Off)
Control	D9	RST	-	Radio Reset
Interrupt	D2	DIO0	-	TX/RX Done Interrupt
Interrupt	D6	DIO1	-	Timeout Interrupt
Interrupt	D7	DIO2	-	Frequency Hopping
UART1	D19 (RX1)	-	TX	Receive data from Bee/GPS
UART1	D18 (TX1)	-	RX	Send data to Bee/GPS

For network integration, The Things Stack (TTS) was used as the LoRaWAN server. It provided packet reception, device management, and storage of metadata such as RSSI, SNR, timestamp, and gateway information. In this project, the end device was activated using the Activation by Personalization (ABP) method. This method was selected because it ensured a simpler and more stable connection during repeated field experiments, especially when the device was frequently restarted at different measurement locations.

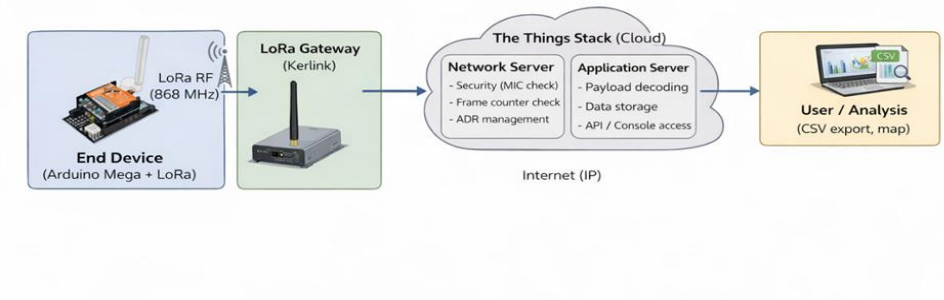

Fig. 2. LoRaWAN system Architecture

2.2 End Device Program Structure

The end device firmware was developed on the Arduino platform for LoRaWAN data transmission and GPS data acquisition. Its main function was to read the current coordinates, form the payload, and send uplink packets to the network server.

The transmission process was implemented using the LMIC library, which controlled LoRaWAN communication and radio parameter configuration. During the experiment, the firmware sequentially applied different transmission settings, including several spreading factors and transmission power levels. The workflow of the program is illustrated in Fig. 3.

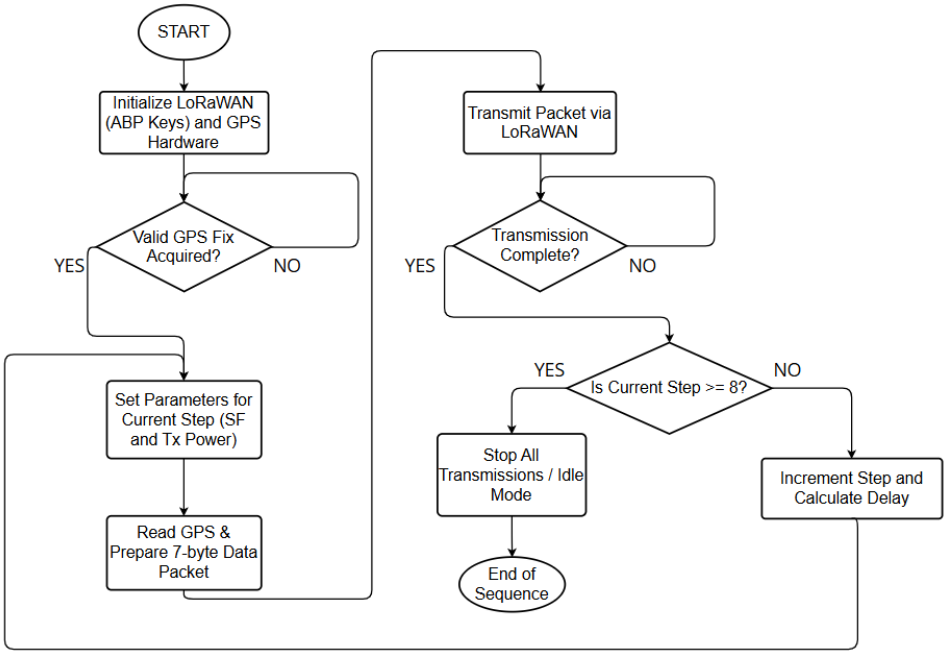

Fig. 3. End device workflow and measurement sequence

The general operation of the firmware consisted of initialization, GPS data acquisition, payload preparation, packet transmission, and repetition of the measurement cycle.

3 Results and outcomes

3.1. Comparison of coverage in different directions

The directional analysis of the measured data showed that the LoRaWAN coverage in Köthen was not uniform. The communication range differed significantly depending on the direction from the gateway location. The best results were obtained in the eastern direction, where packets were successfully received at a distance of about 2.2 km from the gateway. In contrast, the maximum range in the western and southern directions was limited to approximately 1.0 km (Figure 4).

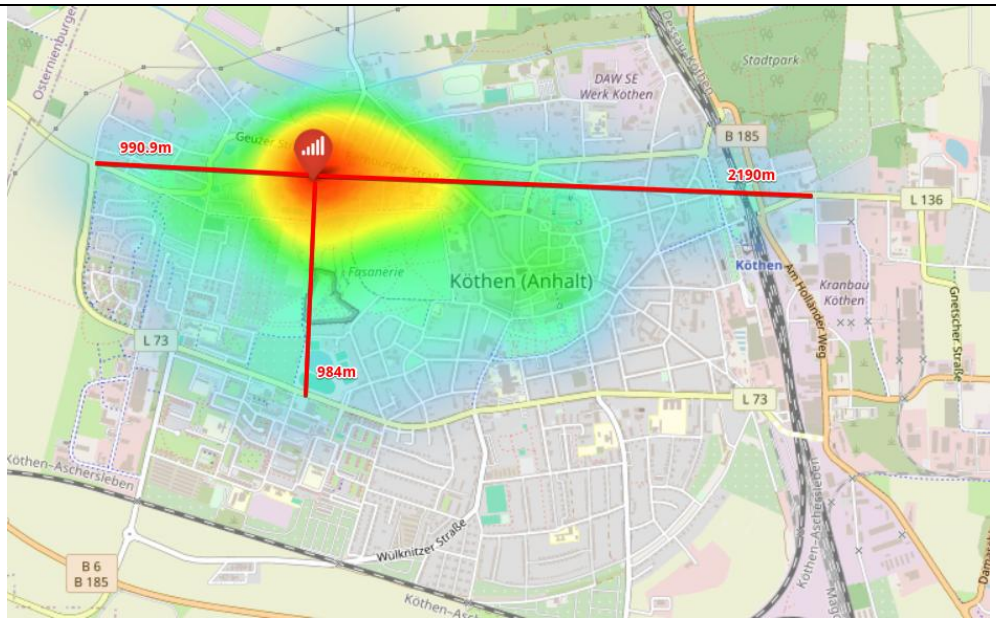

Fig. 4. Comparison of coverage in different directions

As shown in Table 2, the eastern side of the city demonstrated the largest coverage distance, while the western and southern sides showed noticeably shorter communication ranges. These results confirm that gateway placement and surrounding obstacles have a strong influence on LoRaWAN coverage in real urban conditions.

Table 2

Maximum communication distance in different directions

Direction	Maximum distance, m	Latitude	Longitude	RSSI, dBm	SNR, dB
West	991	51.755649	11.945697	-124	-4.8
East	2190	51.754416	11.991777	-124	-16.8
South	984	51.746359	11.962151	-122	-5

3.2. Influence of spreading factor on network coverage

The analysis of the measurement results showed that the spreading factor had a strong influence on the coverage performance of the public LoRaWAN network. At lower spreading factors, such as SF7 and SF8, stable communication was mainly observed in areas close to the gateway. In these cases, the coverage remained limited, and the signal level decreased more rapidly in distant parts of the city.

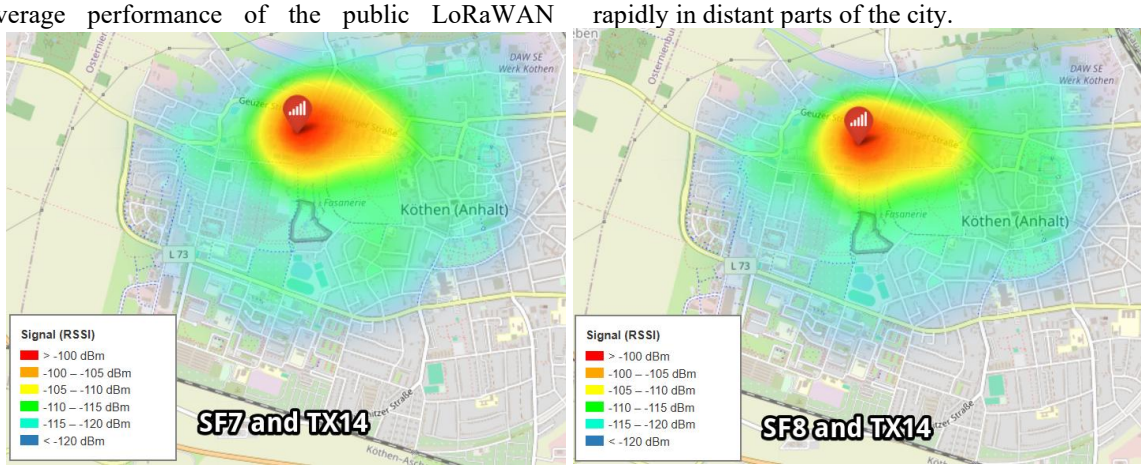

Fig. 5. Coverage comparison for spreading factor 7 and 8 at TX Power(Transmission power) 14dBm

With increasing spreading factor, the communication range and signal stability improved. Configurations from SF9 to SF11 provided a wider coverage area and more reliable reception in urban zones with partial obstruction.

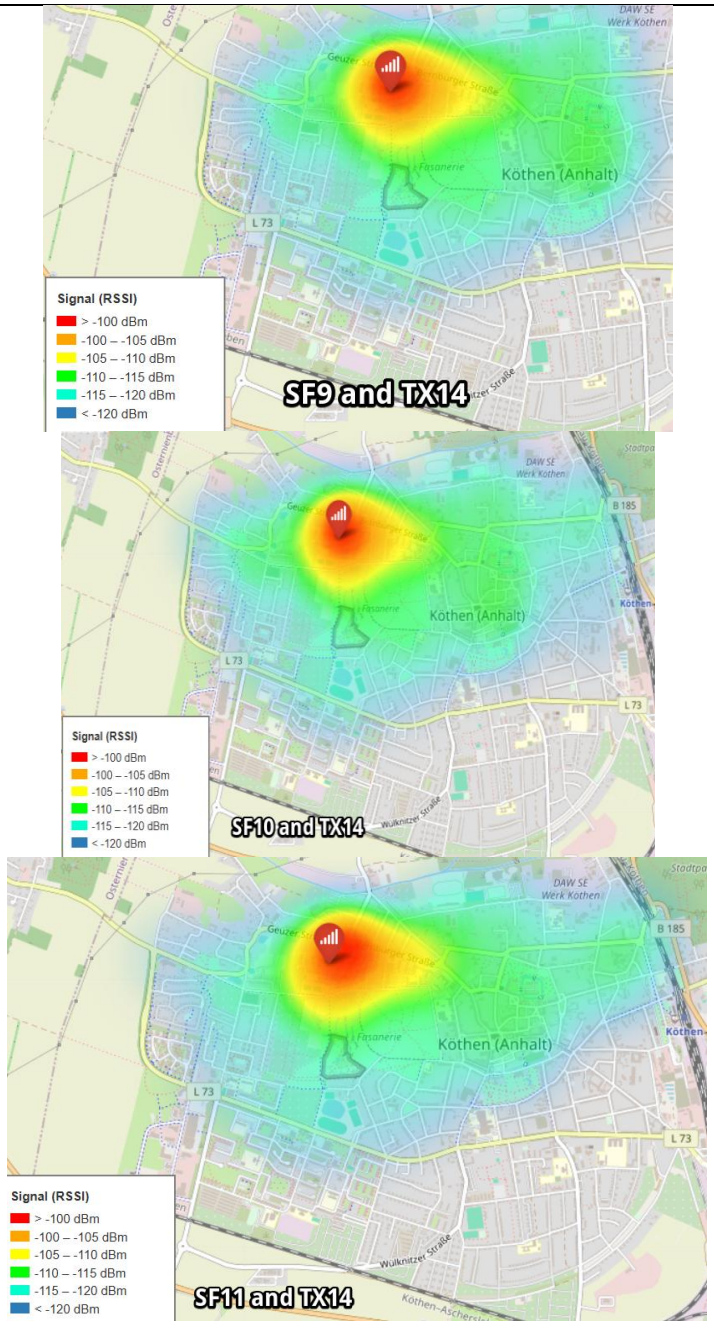

Fig. 6. Coverage comparison for spreading factor 9/10/11 and TX power 14dBm

The best overall result was achieved with SF12 at 14 dBm, which demonstrated the largest coverage area and the highest reliability in weak-signal regions. This configuration allowed packets to be received from the most distant points and showed the best performance in marginal urban areas.

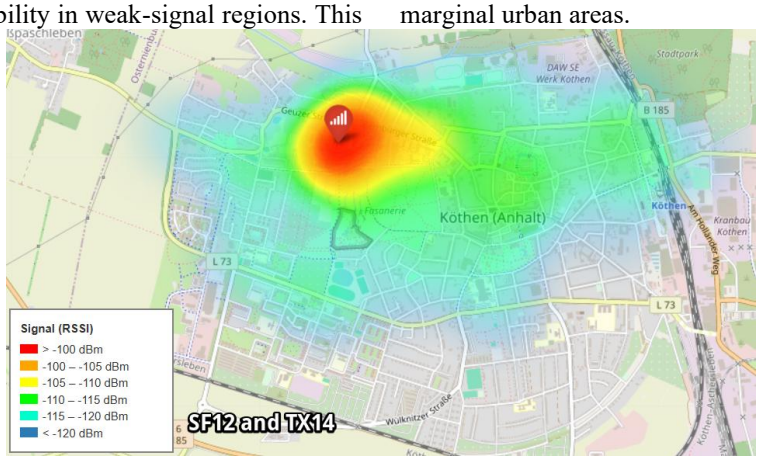

Fig. 7. Spreading factor 12 and TX power 14dBm

As shown in Fig. 7, the gradual increase in spreading factor resulted in a visible expansion of the coverage area. This confirms that higher spreading factors improve receiver sensitivity and make LoRaWAN communication more robust in complex urban environments.

3.3 Overall results of the study

Table 3

Summary of the main experimental results

Parameter	**Main result**
Best coverage direction	East side of Köthen
Maximum range	About 2.2 km
Lower coverage directions	West and South, about 1.0 km
Best spreading factor	SF12
Best transmission setting	SF12 at 14 dBm
Effect of lower TX power	Reduced coverage and weaker signal
Main influencing factors	Gateway placement, spreading factor, transmission power, urban obstacles

Table 3 summarizes the main findings of the study. The best overall performance was achieved in the eastern direction. This can be explained by the gateway installation conditions: the antenna was placed near a window on the fifth floor of the dormitory building, and the window was oriented toward the east side. As a result, signal propagation in that direction was less obstructed, while the west and south directions were more affected by the building structure and surrounding urban obstacles.

4 Conclusion

This study presented an experimental evaluation of a public LoRaWAN network in the urban environment of Köthen using an Arduino Mega 2560, a Dragino LoRa/GPS Shield, a Kerlink Wirnet Station gateway, and The Things Stack as the network server.

The results showed that spreading factors 7 and 8 provided stable communication mainly in areas close to the gateway, where the signal conditions were more favorable. Spreading factors 9, 10, and 11 demonstrated improved coverage and more reliable reception in wider urban areas, indicating better resistance to attenuation and partial obstruction. The best overall result was obtained with spreading factor 12, which provided the widest coverage area and the most stable communication at the most distant measurement points.

Overall, the obtained results confirm that practical LoRaWAN performance in urban environments depends strongly on spreading factor selection, gateway placement, and surrounding obstacles. These findings can be useful for further planning and optimization of public LoRaWAN deployments.

References

1. Augustin, A., Yi, J., Clausen, T., Townsley, W. M., A Study of LoRa: Long Range & Low Power Networks for the Internet of Things, Sensors, vol. 16, no. 9, pp. 1466, September, 2016.

2. Adelantado, F., Vilajosana, X., Tuset-Peiro, P., Martinez, B., Melia-Segui, J., Watteyne, T., Understanding the Limits of LoRaWAN, IEEE Communications Magazine, vol. 55, no. 9, pp. 34-40, September, 2017.

3. Haxhibeqiri, J., De Poorter, E., Moerman, I., Hoebeke, J., A Survey of LoRaWAN for IoT: From Technology to Application, Sensors, vol. 18, no. 11, pp. 3995, November, 2018.

4. Dragino Technology Co., Limited, LoRa GPS Shield User Manual, [Online]. Available: https://www.dragino.com/products/lora/item/108-lora-gps-shield.html. [Accessed: Dec. 13, 2025].

5. Kerlink, Wirnet iStation Gateway Technical Specifications, [Online]. Available: https://www.kerlink.com/product/wirnet-istation/. [Accessed: Feb. 19, 2026].

6. The Things Industries, The Things Stack Documentation: Spreading Factors and RSSI Analysis, [Online]. Available: https://www.thethingsindustries.com/docs/. [Accessed: Oct. 10, 2025].

7. Petajajarvi, J., Mikhaylov, K., Roivainen, A., Haapola, J., Pouttu, A., On the Coverage of LPWANs: Range Evaluation and Channel Attenuation Model for LoRa Technology, 2015 14th International Conference on ITS Telecommunications (ITST), pp. 55-59, December, 2015.

8. Raza, U., Kulkarni, P., Sooriyabandara, M., Low Power Wide Area Networks: An Overview, IEEE Communications Surveys & Tutorials, vol. 19, no. 2, pp. 855-873, Second Quarter, 2017.

9. Centenaro, M., Vangelista, L., Zanella, A., Zorzi, M., Long-range communications in unlicensed bands: the rising stars in the IoT and smart city scenarios, IEEE Wireless Communications, vol. 23, no. 5, pp. 60-67, October, 2016.

10. Wixted, A. J., Larijani, P., Postolache, A., Fowler, K., Evaluation of LoRa Technologies for Smart City Applications, 2016 IEEE International Conference on Renewable Energy Research and Applications (ICRERA), pp. 1139-1144, November, 2016.

LEGUME CROPSIMPROVING THE TECHNOLOGY OF VEGETABLE SALADS BY ADDING

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Abstract
Currently, improving the quality of public nutrition and creating food products with high biological value is one of the priority areas of the food industry. Although salads are a widely consumed food in the human diet, the issue of increasing their protein content remains relevant. In this regard, enriching traditional vegetable products with legumes, which are rich in plant protein, is an innovative direction for improving nutrition.
Keywords: vegetable salads, legume crops, beans, protein value, lecho technology, nutritional value, preservation.

Salads are a widely consumed food in the human diet. They are prepared by mixing various vegetables, fruits, greens, grains, and legumes. The main characteristic of salads is the preservation of a large amount of natural vitamins and minerals due to the fact that the ingredients are not heat-treated. Vegetable salads, in particular, are valued as low-calorie but high-nutritional and biological value foods.

Daily consumption of salads provides the body with biologically active substances, improves digestion, and strengthens the immune system. In addition, pectin substances and dietary fiber in vegetables help lower cholesterol levels in the body and regulate metabolism.

Traditionally, vegetables such as potatoes, carrots, cucumbers, tomatoes, cabbage, and corn are often used in salads. However, in recent years, adding legumes to salads has become widespread and an effective way to increase their protein value. This is an innovative direction for improving nutrition, which enhances the nutritional quality and biological significance of salads.

Legume crops are richin complete proteins, carbohydrates, fats, vitamins, and minerals (Table 1).

Table 1.

Chemical composition of legume crops, g

Rawmaterial	protein	fat	monosaccharide	starch	fiber	K	PP	Energy value, kcal
Red kidney bean	22	1,5	3,0	44,0	6,4	1350	2,0	333
White kidney bean	21	1,6	3,2	44,0	6,0	1180	2,1	333
Green peas	23	2,0	4,5	41,0	5,0	990	1,6	298

Legume crops are several times higher than beef in terms of the amount of mineral elements such as potassium, calcium, magnesium, phosphorus, and iron. crops In addition, legumes are a major source of Band PP vitamins. are. Kidneybeans have a low content of fat, and the content of essential amino acids is several times higher compared to other grains and milk (Figure 1). compared to

Figure 1. Legume crops

In the course of scientific work, various legume crops were used to enrich vegetable preserves with plant protein, i.e., the assortment of vegetable salads was intended to be expanded by enriching their composition with plant protein, i.e., salads were prepared according to the following recipes:

traditional lecho made in tomato sauce in sample No. 1 – bell pepper, tomato, cucumber, carrot, vegetable oil;

lecho with added beans in tomato sauce in sample No. 2 – bell pepper, white and red kidney beans, tomato, carrot, vegetable oil.

The nutritional, energetic, and biological value of the new salad varieties obtained was determined (Table 2).

Table 2.

Of new vegetable salads samples main indicators determined in the laboratory

Product name	aProtein, %	мFat, %	кWater, %	K, mg	PP, mg	Energy value, kcal
Sample No. 1	1,18	3,24	8,77	288	0,96	65,7
Sample No. 2	2,47	2,28	10,78	330	086	70,3

Energy value usually refers to the amount of energy a person receives from a particular food. It is usually measured in kilocalories (kcal) or joules (J). When it comes to the nutritional value of food products, it usually refers to the proteins, fats, and carbohydrates contained in it, which are the main source of energy for our body. The biological value of products depends on the content of essential amino acids, vitamins, and minerals in their composition. Related literature: related.

References

1. Syzdykova, L.S. Technology of canned and food products [Text/Electronic resource]: Textbook. - Almaty: ATU, 2015. - 150 p. - ISBN 978-601-263-256-9.

2. Plant growing: textbook [Text]. In 3 parts. Part 1. Cereal and leguminous crops / V.M. Fedorova, N.N. Yarkova, S.L. Eliseev; ed. by S.L. Eliseev; Ministry of Agriculture of the Russian Federation, Federal state budgetary educationalinstitution of higher professional education«Perm State Agricultural Academy named after Academician D.N. Pryanishnikov». – Perm: IPC «Prokrost'», 2014. – 112 p.

3. Markov P. Beneficial and dietary characteristics of legumes based on medical evidence / P. Markov, D. Markov, A. Vodenicharova // World Ecology Journal, 2016. - Vol. 6., No. 12. - pp. 24-30.

4. Leguminous crops: practical work / V. G. Taranukho [et al.]. – Gorki: BGSKhA, 2014. – 56 p.

5. Syzdykova L.S., Fruit and vegetableөcanning technology, textbook - Almaty 2019, - 172 pages.

6. Chemical composition of food products / A. A. Pokrovsky. — Moscow: Pishchevaya Promyshlennost, 1976. — 228 p.

7. Timofeeva, V. N. Technology of fruit and vegetable canning: textbook. – Minsk: BGATU, 2021. – 220 p.

8. Sabit R., Syzdykova L.S., Abdieva K.M. KTypes and properties of legumes used in the production of vegetable preserves. Materials of the international scientific-practical conference dedicated to the 80th anniversary of Academician of the National Academy of Sciences of the Republic of Kazakhstan Kuralbek Sadibayuly Kulazhanov "Modern development trends of chemical technology and engineering in food and industries" February 23, 2023, 221 p..

9. Syzdykova L.S., Abdieva K.M., Karim E.K., Sabit R. БTechnology for preparing natural vegetable preserves with legumes. MATERIALS of the Republican Scientific-Practical Conference of Young Scientists "Science. Education. Youth" April 20-21, 2023, - pp. 33-34.

10. Agidullina B.Zh., Kabylbekova A.B. Ways to increase the nutritional and biological value of vegetable preserves // "Agro-industrial complex" collection of scientific works. – Almaty: Kazakh National Agrarian University, 2016. – Vol. 2. – pp. 115–118.

ВЛИЯНИЕ СУ-ВИД ОБРАБОТКИ НА КАЧЕСТВО МЯСНЫХ ИЗДЕЛИЙ

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THE IMPACT OF SOUS-VIDE PROCESSING ON THE QUALITY OF MEAT PRODUCTS

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Аннотация

В статье рассмотрено влияние низкотемпературной технологии су-вид на качество мясных изделий. Представлен анализ физико-химических и органолептических изменений, происходящих в мясных полуфабрикатах в процессе длительной тепловой обработки при контролируемых температурах в условиях вакуума. Установлено, что применение технологии су-вид способствует равномерному прогреву продукта, снижению потерь влаги и массы, а также сохранению структурной целостности мышечных волокон. Показано, что данный метод обеспечивает высокую сочность, нежную консистенцию и выраженные вкусовые характеристики готовых изделий. Отмечено увеличение относительного содержания жира вследствие минимальных потерь влаги и сохранения липидной фракции внутри продукта. В то же время выявлено снижение массовой доли белка, связанное с перераспределением растворимых белковых компонентов. Сделан вывод о целесообразности использования технологии су-вид как эффективного способа повышения качества мясной продукции и оптимизации технологических процессов.

Abstract

This article examines the impact of low-temperature sous-vide cooking on the quality of meat products. It analyzes the physicochemical and organoleptic changes occurring in semi-finished meat products during prolonged heat treatment at controlled temperatures under vacuum. It is established that sous-vide cooking promotes uniform heating of the product, reduces moisture and weight loss, and preserves the structural integrity of muscle fibers. This method is shown to ensure high juiciness, a delicate texture, and distinct flavor characteristics in finished products. An increase in the relative fat content is noted due to minimal moisture loss and preservation of the lipid fraction within the product. At the same time, a decrease in protein content is observed due to the redistribution of soluble protein components. It is concluded that sous-vide cooking is an effective way to improve the quality of meat products and optimize technological processes.

Ключевые слова: су-вид; низкотемпературная обработка; мясные изделия; тепловая обработка; качество продукции; органолептические показатели; физико-химические свойства; влагосвязывающая способность; белки; жиры; вакуумная упаковка.

Keywords: sous vide; low-temperature processing; meat products; heat treatment; product quality; organoleptic properties; physicochemical properties; moisture-binding capacity; proteins; fats; vacuum packaging.

В современных условиях развития пищевой промышленности и общественного питания особое внимание уделяется внедрению инновационных технологий, направленных на повышение качества и безопасности продукции. Рост требований со стороны потребителей к органолептическим характеристикам, пищевой ценности и стабильности свойств мясных изделий обусловливает необходимость поиска и научного обоснования новых методов тепловой обработки.

Одним из наиболее перспективных направлений является технология низкотемпературного приготовления су-вид (sous-vide), которая в последние годы получила широкое распространение как в профессиональной кулинарии, так и в промышленном производстве. Данный метод основан на сочетании вакуумной упаковки сырья и длительной тепловой обработки при строго контролируемых температурах, что позволяет принципиально изменить характер протекающих в продукте физико-химических процессов.

Актуальность исследования технологии су-вид обусловлена её способностью обеспечивать высокую сохранность пищевой ценности мясного сырья, минимизировать потери массы и влаги, а также формировать улучшенные органолептические характеристики готовых изделий. В отличие от традиционных методов тепловой обработки, сопровождающихся значительными температурными градиентами и интенсивной денатурацией белков, су-вид позволяет осуществлять более щадящее воздействие на структуру продукта, сохраняя его сочность, нежность и естественный вкус.[1]

Особый интерес представляет влияние данной технологии на физико-химические показатели мясных изделий, включая изменение содержания белка, жира и влаги, а также на формирование текстурных характеристик. В условиях вакуума и ограниченного доступа кислорода существенно снижаются окислительные процессы, что положительно сказывается на стабильности липидной фракции и сохранении биологически активных компонентов.

Целью настоящего исследования является изучение влияния технологии су-вид на качество мясных изделий с позиции изменения их физико-химических и органолептических показателей.

Для достижения поставленной цели были определены следующие задачи:

– проанализировать особенности технологии су-вид и её место среди современных методов тепловой обработки;

– изучить влияние низкотемпературного воздействия на структурно-механические свойства мясных изделий;

– оценить изменения химического состава продукции в процессе обработки;

– провести органолептическую оценку готовых изделий и определить их потребительскую привлекательность.

Таким образом, исследование технологии су-вид представляет собой актуальное научно-практическое направление, способствующее совершенствованию технологических процессов производства мясной продукции и повышению её конкурентоспособности на современном рынке.

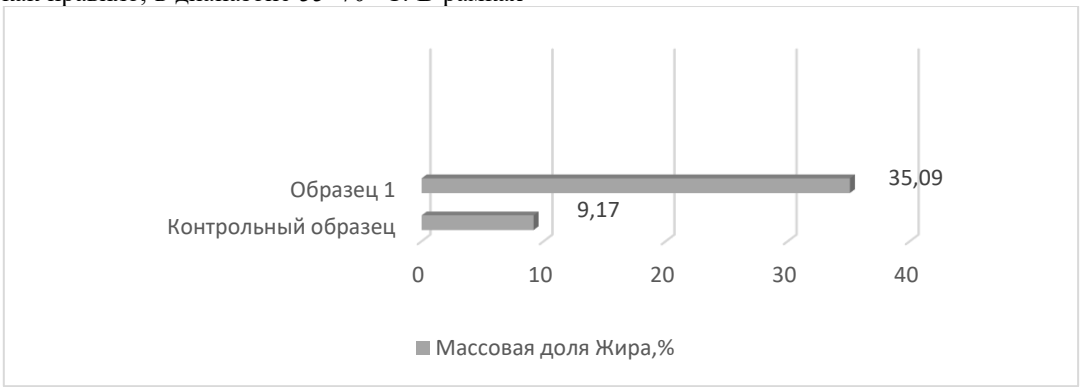
Низкотемпературная обработка методом су-вид (sous-vide) представляет собой современную инновационную технологию приготовления мясных продуктов, основанную на длительном нагреве сырья при строго контролируемых температурах в вакуумной упаковке. Данный метод получил широкое распространение в пищевой промышленности и сфере общественного питания благодаря способности обеспечивать высокую стабильность качества готовой продукции.[2]

Сущность технологии заключается в герметичном вакуумировании продукта с последующей тепловой обработкой в водяной среде при температуре, как правило, в диапазоне 55–70 °С. В рамках проведённого исследования котлетные полуфабрикаты подвергались обработке при температуре 65 ± 1 °С в течение 90 минут, что соответствует оптимальным условиям денатурации мышечных белков без их избыточного разрушения.

Физико-химические изменения, происходящие в мясной системе при низкотемпературной обработке, имеют принципиально иной характер. Денатурация белков протекает медленно и контролируемо, что способствует сохранению влагосвязывающей способности тканей. В результате готовый продукт характеризуется повышенной сочностью и нежной текстурой. Кроме того, вакуумная среда исключает контакт с кислородом, что предотвращает окисление липидов и деградацию чувствительных биологически активных веществ.[3]

Особое значение имеет влияние технологии су-вид на содержание жировой фракции. В условиях герметичной упаковки отсутствует вытопление жира и его потеря, что приводит к сохранению всех липидных компонентов внутри продукта. Это объясняет увеличение массовой доли жира в готовых изделиях до 35,09 %, что, однако, связано не с абсолютным приростом жира, а с уменьшением потерь влаги и концентрацией сухих веществ.

Содержание белка в образцах, приготовленных методом су-вид, оказалось ниже по сравнению с альтернативными способами тепловой обработки. Это может быть обусловлено перераспределением растворимых белковых фракций внутри системы и их частичным переходом в выделяющийся мясной сок. Тем не менее, следует отметить, что биологическая ценность белка при этом сохраняется в высокой степени, поскольку мягкие температурные условия препятствуют глубокой деструкции аминокислот.



Контрольный образец – Котлетный фарш; Образец 1 – Котлеты приготовленные методом су-вид;

С точки зрения органолептических показателей технология су-вид продемонстрировала наилучшие результаты. Образцы характеризовались выраженным мясным вкусом, однородной консистенцией, высокой сочностью и отсутствием пересушенных участков. Формирование вкусо-ароматического профиля при этом происходит преимущественно за счёт естественных компонентов сырья, без интенсивных реакций Майяра, характерных для высокотемпературных методов обработки.[4]

Дополнительным преимуществом метода является снижение потерь массы продукта. В ходе исследования установлено, что при использовании технологии су-вид потери составляют около 17 %, что ниже по сравнению с традиционными способами тепловой обработки. Это имеет важное экономическое значение для предприятий общественного питания и мясоперерабатывающей промышленности.

Таким образом, технология су-вид является эффективным инструментом повышения качества мясных изделий. Она обеспечивает оптимальное

сочетание физико-химических и органолептических характеристик, способствует сохранению пищевой ценности и позволяет получать продукт с высокой степенью потребительской привлекательности. Перспективы дальнейшего применения данного метода связаны с его внедрением в массовое производство, разработкой новых рецептур и оптимизацией режимов обработки в зависимости от вида мясного сырья.

Список литературы

1. Родионова, Н. С. Исследование процесса sous-vide обработки полуфабриката говядины / Н. С. Родионова, Е. С. Попов, Р. О. Гончаров // Инновационные технологии в пищевой промышленности: наука, образование и производство: Международная научно-техническая конференция (заочная), Воронеж, 03–04 декабря 2013 года. – Воронеж: Воронежский государственный университет инженерных технологий, 2013. – С. 348. – EDN TDCZRX.

2. Родионова Наталья Сергеевна, Попов Евгений Сергеевич Sous-vide обработка мелкокусковых полуфабрикатов из мяса говядины: режимы и показатели качества // Пищевая промышленность. 2015. №10. URL: https://cyberleninka.ru/article/n/sous-vide-obrabotka-melkokuskovyh-polufabrikatov-iz-myasa-govyadiny-rezhimy-i-pokazateli-kachestva (дата обращения: 13.04.2026).

3. Саткеева, А. Б. Влияние технологии "Sous-vide" на качественные показатели говядины / А. Б. Саткеева, А. А. Каменцев // Актуальные вопросы науки и хозяйства: новые вызовы и решения: Сборник материалов LIII Международной студенческой научно-практической конференции, Тюмень, 29 марта 2019 года. Том Часть 3. – Тюмень: Государственный аграрный университет Северного Зауралья, 2019. – С. 121-124. – EDN LCXHUH.

4. Технология sous-vide для производства продуктов из говядины / В. В. Насонова, Е. К. Туниева, Е. В. Милеенкова, А. А. Мотовилина // Мясная индустрия. – 2022. – № 2. – С. 27-32. – DOI 10.37861/2618-8252-2022-02-27-32. – EDN NYSKME.

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